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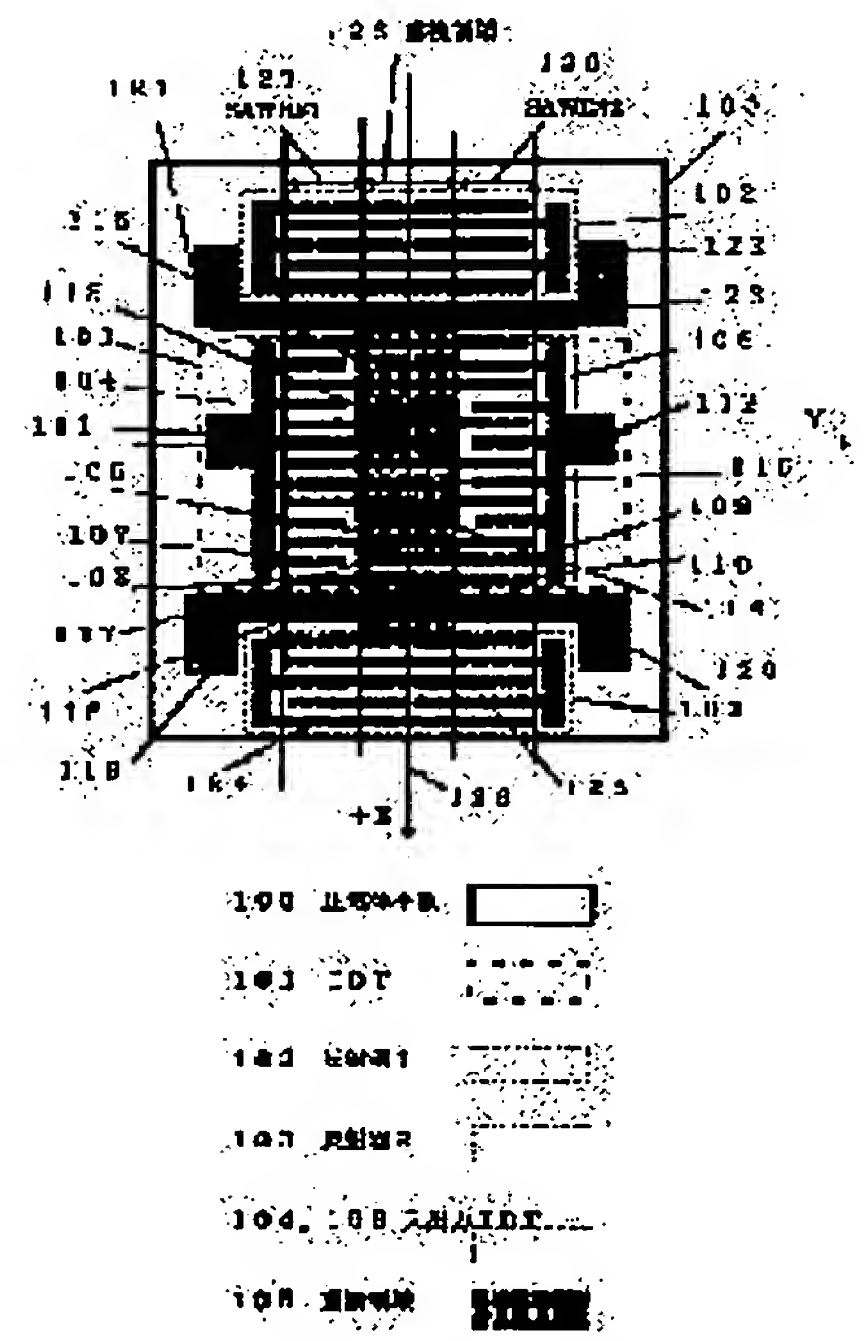
(54) LATERAL DUAL MODE SAW FILTER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an excellent intermediate frequency filter applicable to a portable telephone set such as a PHS and a GSM by attaining a broad frequency band and miniaturization of the lateral dual mode SAW filter (high frequency narrow band multiplex mode filter) employing, e.g. a crystal substrate.
SOLUTION: In th case of integrating IDTs 101 of two SAW resonators 127, 129, a frequency of a basic wave symmetrical mode SO of two specific vibration modes in use is decreased by arranging a shared feed-conductor pattern (bus bar) on the negative polarity side in such a way that a plurality (two or over) of positions are taken in the width direction and this arrangement is repeated periodically in a propagation direction X of a surface acoustic wave, thereby extending the pass band width of the filter.



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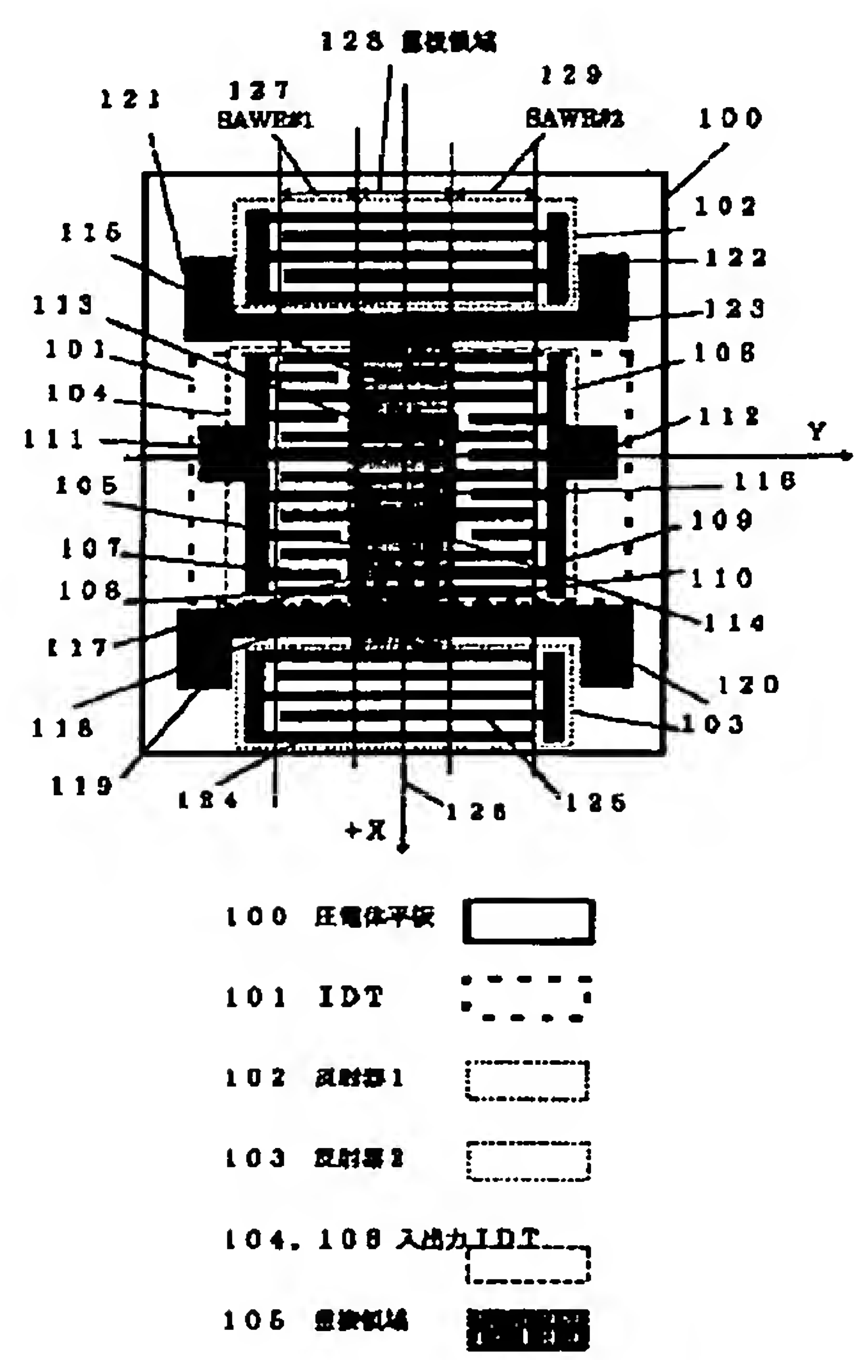
(54) 【発明の名称】横２重モードＳＡＷフィルタ

(57) 【要約】

【課題】　例えば水晶基板を用いた横２重モードＳＡＷフィルタの広帯域幅化と小型化を図り、ＰＨＳ、ＧＳＭ等の携帯電話用途に対して優れた中間周波フィルタを提供すること。

【解決手段】　２つＳＡＷ共振子のＩＤＴを結合し一体化するに際して、共用する負極性側の給電導体パターン（バスバー）を、幅方向に２つ以上の複数の位置をとって周期的に弾性表面波の伝搬方向Ｘに繰り返すように配置することにより、利用する２つの固有振動モードのうち、基本波対称モードＳ０の周波数を低下せしめてフィルタの通過帯域幅を広げたことを特徴とする。



【特許請求の範囲】

【請求項１】　圧電体平板上に、少なくとも１個のすだれ状電極と、前記すだれ状電極が発生する弾性表面波をその両側において反射するための、１対の反射器を有した２個のＳＡＷ共振子を、前記弾性表面波の伝搬方向Ｘに対して相隣接してほぼ平行に配置した横２重モードＳＡＷフィルタにおいて、

前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体を、一体にして共用し、かつ前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を複数とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣが複数の寸法をとりＸ方向にそって交互に変化していることを特徴とする横２重モードＳＡＷフィルタ。

【請求項２】　前記すだれ状電極が有する負極側の給電導体のＹ方向の座標位置が、２つのＹ座標（Ｙ１，Ｙ２）を交互にとるようにしたことを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項３】　前記共用するすだれ状電極の負極側の給電導体について、幅方向に横断する部位（１１３，１１４）のＸ方向電極幅が、弾性表面波の波長をλとして、λ／４の奇数倍であることを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項４】　前記すだれ状電極の幅方向に重複する領域の寸法WC_{12}が、弾性表面波の波長をλとして、２λ以上から５λ以下の範囲であることを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項５】　前記横２重モードＳＡＷフィルタの伝送特性が、横モードに属する基本波対称モードＳ０と基本波斜対称モードＡ０とから合成されていることを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項６】　前記圧電体平板が水晶であって、３０～４５度回転Ｙ板のＳＴカットＸ伝搬方位であることを特徴とする請求項１記載の横多重モードＳＡＷフィルタ。

【請求項７】　前記圧電体平板が水晶であって、３０～４５度回転Ｙ板のＳＴカットであり、かつ前記すだれ状電極の幅の合計（$WC_T=WC_1+WC_2+WC_{12}+G_1+G_2$）が、弾性表面波の波長をλとして、１２λから２０λの範囲したことを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項８】　前記１個のＳＡＷ共振子が有するすだれ状電極の対数が１２０対から６０対の範囲かつ片側反射器の導体本数が８０本から１４０本の範囲内であることを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項９】　前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体を、幅方向中央において２つに分離して、これによって入出力側端子対間を電気的に絶縁したことを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項１０】　前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体が、前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を偶数回とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣの変化が、前記Ｘ軸方向の中央線に対して線対称であることを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項１１】　前記すだれ状電極の正負極性の電極指が交差する幅ＷＣＡが、前記２個のＳＡＷ共振子の幅方向中央線を越えないように、いずれか一方の極性の電極指パターンを細い導体なしの部位を設けて分割分離したことを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項１２】　前記２個のＳＡＷ共振子が有するすだれ状電極の正負極性の電極指が交差する幅ＷＣＡが形成する電極総面積が相互に等しくかつ、前記基本波対称モードＳ０と基本波斜対称モードＡ０に関する相互の電極総面積もほぼ等しいことを特徴とする請求項１記載記載の横２重モードＳＡＷフィルタ。

【請求項１３】　前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体が、前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を偶数回とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣＡの変化が、前記Ｘ軸方向の中央線に対して線対称となし、

前記すだれ状電極の正負極性の電極指が交差する幅ＷＣＡが、前記２個のＳＡＷ共振子の幅方向中央線を越えないように、電極指パターンを細い導体なしの部位を設けて分割分離し、

前記２個のＳＡＷ共振子が有するすだれ状電極の正負極性の電極指が交差する幅ＷＣＡが形成する電極総面積が相互に等しくかつ、前記基本波対称モードＳ０と基本波斜対称モードＡ０に関する相互の電極総面積もほぼ等したことを合わせ有することを特徴とする請求項１記載の横２重モードＳＡＷフィルタ。

【請求項１４】　前記横２重モードＳＡＷフィルタを２段縦属接続したことを特徴とする請求項1から１３のいずれかに記載の横２重モードＳＡＷフィルタ。

【請求項１５】　圧電体平板上に、少なくとも１個のすだれ状電極と、前記すだれ状電極が発生する弾性表面波をその両側において反射するための、１対の反射器を有した２個のＳＡＷ共振子を、前記弾性表面波の伝搬方向Ｘに対して相隣接してほぼ平行に配置した横２重モードＳＡＷフィルタにおいて、

前記２個のＳＡＷ共振子が有する交差電極指幅ＷＣでもって形成されるすだれ状電極及び反射器領域の幅方向の外側に、空間長Ｇを隔てて、横１次対称モードＳ１の振動変位を漏洩させて減衰させるように構成した、同一極性のみからなる電極指群で形成される幅ＢＰのグレイティング状の電極領域を設けたことを特徴とする横２重モ

ードＳＡＷフィルタ。

【請求項１６】　前記空間長Ｇが弾性表面波の２波長から３波長であり、かつ前記グレイティング状の電極領域の幅ＢＰが３波長から４波長であることを特徴とする請求項１５記載の横２重モードＳＡＷフィルタ。

【請求項１７】　前記グレイティング状の電極領域を形成する電極指群の端部を短絡して電流を供給する給電導体の内側が、前記弾性表面波の伝搬方向Ｘ軸方向にそってテーパ状の形状をなしたことを特徴とする請求項１５記載の横２重モードＳＡＷフィルタ。

【請求項１８】　前記グレイティング状の電極領域を形成する電極指群の端部を短絡して電流を供給する給電導体の内側が、前記弾性表面波の伝搬方向Ｘ軸方向にそって２度から３度のテーパ状の形状をなしたことを特徴とする請求項１７記載の横２重モードＳＡＷフィルタ。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は弾性表面波を利用して構成される共振子型ＳＡＷフィルタにおいて、ＳＡＷ共振子を２つ横に平行配置して得られる２個の独立した横モードを利用して、フィルタの広帯域化を実現した横２重モードＳＡＷフィルタに関する。

【０００２】

【従来の技術】従来の共振子型の横２重モードＳＡＷフィルタとしては、横に２個のＳＡＷ共振子を平行配置した、いわゆる横２重モードＳＡＷフィルタ（別名では、高周波狭帯域多重モード・フィルタ）が有名である（特公平２－１６６１３号公報）。この方式を用いて周波数温度特性が優れた、約３０度から４５度の回転Ｙ板である水晶ＳＴカットＸ伝搬基板にてフィルタを構成すると、素子の平面サイズが２mm×６．５mmで、２段従属接続フィルタの３ｄＢ帯域幅が比帯域幅で表現して約７００ｐｐｍ、かつ挿入損失５ｄＢの優れた特性が得られている。

【０００３】

【発明が解決しようとする課題】しかし前述の横２重モードＳＡＷフィルタの従来技術を使用しては、近年著しい発展を見せているＧＳＭ方式とかＰＨＳ方式の携帯電話に用いられる中間周波フィルタ（ＩＦフィルタ）において要求される、１）９００から１０００ｐｐｍの比帯域幅をもち、２）かつ容器の平面サイズ３．８×３．８mm以内のものが、前記水晶ＳＴカットでは満足できる性能では実現できなかった。

【０００４】実現できない原因を分析するとまず、１）の課題である比帯域幅については、前述の従来技術において妥当なフィルタインピーダンスZ_0が得られる１個のＳＡＷ共振子の幅寸法７から９波長において、前記の比帯域幅を決定している２つの独立な固有モードＳ０（基本波対称モード）とＡ０（基本波斜対称モード）の周波数差が７００ｐｐｍ程度で、これ以上に大きくならないことによる。つぎに２）の課題であるサイズについては、前記の容器平面サイズ内に素子を収納する場合には、素子サイズが２×３mm程度となり、１個のＳＡＷ共振子を構成するすだれ状電極（以降、省略してＩＤＴ（Interdigital Transducer）と略記する）の正負電極を１対とした電極指対数Ｍ対と片側の反射器導体本数Ｎの和　Ｍ＋Ｎを約２００本以下にすることが必要となる。このため、横２重モードＳＡＷフィルタを構成するＳＡＷ共振子の共振振幅の励振強度および変位伝達係数が減少して、前記ＳＡＷフィルタの伝送特性がただでさえ劣化することになる。

【０００５】さらに、第３の課題として、前記の伝送特性の内の一特性である挿入損失を改善するために、反射器導体本数の不足分を補う目的で、電極膜厚みを厚くすることが考えられるが、これによって縦及び横高次モードスプリアスのレベルが増加することになる。

【０００６】そこで本発明はこのような問題点を解決するもので、その目的は、水晶ＳＴカットのような周波数温度特性が優れ、かつ材料のＱ値が優れた基板を用いて、従来に無く通過帯域幅の広帯域化と小型化をはかり、周波数安定度に優れかつＳ／Ｎが良いＩＦフィルタを市場に提供することにある。

【０００７】

【課題を解決するための手段】（１）本発明の横２重モードＳＡＷフィルタは、圧電体平板上に、少なくとも１個のすだれ状電極と、前記すだれ状電極が発生する弾性表面波をその両側において反射するための、１対の反射器を有した２個のＳＡＷ共振子を、前記弾性表面波の伝搬方向Ｘに対して相隣接してほぼ平行に配置した横２重モードＳＡＷフィルタにおいて、前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体を、一体にして共用し、かつ前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を複数とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣが複数の寸法をとりＸ方向にそって交互に変化していることを特徴とする。

【０００８】（２）前記（１）において、前記すだれ状電極が有する負極側の給電導体のＸ方向座標位置が、２つのＹ座標（Ｙ１，Ｙ２）を交互にとるようにしたことを特徴とする。

【０００９】（３）前記（１）において、前記共用するだれ状電極の負極側の給電導体について、幅方向に横断する部位（１１３、１１４）のＸ方向電極幅が、弾性表面波の波長をλとして、λ／４の奇数倍であることを特徴とする。

【００１０】（４）前記（１）において、前記２つのＳＡＷ共振子の有する電極指交差幅が、幅方向について重複する領域の寸法WC_{12}が、弾性表面波の波長をλとして、２λ以上から５λ以下の範囲であることを特徴とする。

【００１１】（５）前記（１）において、前記横２重モードＳＡＷフィルタの伝送特性が、横モードに属する基本波対称モードＳ０と基本波斜対称モードＡ０とから合成されていることを特徴とする。

【００１２】（６）前記（１）において、前記圧電体平板が水晶であって、３０～４５度回転Ｙ板のＳＴカットＸ伝搬方位であることを特徴とする。

【００１３】（７）前記（１）において、前記圧電体平板が水晶であって、３０～４５度回転Ｙ板のＳＴカットであり、かつ前記すだれ状電極の幅の合計（$WC_T=WC_1+WC_2+WC_{12}+G_1+G_2$）が、弾性表面波の波長をλとして、１２λから２０λの範囲したことを特徴とする。

【００１４】（８）前記（１）において、前記１個のＳＡＷ共振子が有するすだれ状電極の対数が１２０対から６０対の範囲かつ片側反射器の導体本数が８０本から１４０本の範囲内であることを特徴とする。

【００１５】（９）前記（１）において、前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体を、幅方向中央において２つに分離して、これによって入出力側端子対間を電気的に絶縁したことを特徴とする。

【００１６】（１０）前記（１）において、前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体が、前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を偶数回とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣＡの変化が、前記Ｘ軸方向の中央線に対して線対称であることを特徴とする。

【００１７】（１１）前記（１）において、前記すだれ状電極の正負極性の電極指が交差する幅ＷＣＡが、前記２個のＳＡＷ共振子の幅方向中央線を越えないように、いずれか一方の極性の電極指パターンを細い導体なしの部位を設けて分割分離したことを特徴とする。

【００１８】（１２）前記（１）において、前記２個のＳＡＷ共振子が有するすだれ状電極の正負極性の電極指が交差する幅ＷＣＡが形成する電極総面積が相互に等しくかつ、前記対称モードＳ０と斜対称モードＡ０に関する相互の電極総面積もほぼ等しいことを特徴とする。

【００１９】（１３）前記（１）において、前記２個のＳＡＷ共振子が有するすだれ状電極の負極側の給電導体が、前記の伝搬方向Ｘに直交する幅方向に折れる座標位置を偶数回とって矩形波状をなして形成し、これによって前記すだれ状電極の交差電極指幅ＷＣＡの変化が、前記Ｘ軸方向の中央線に対して線対称となし、前記すだれ状電極の正負極性の電極指が交差する幅ＷＣＡが、前記２個のＳＡＷ共振子の幅方向中央線を越えないように、電極指パターンを細い導体なしの部位を設けて分割分離し、前記２個のＳＡＷ共振子が有するすだれ状電極の正負極性の電極指が交差する幅ＷＣＡが形成する電極総面積が相互に等しくかつ、前記対称モードＳ０と斜対称モードＡ０に関する相互の電極総面積もほぼ等しくしたことを合わせ有することを特徴とする。

【００２０】（１４）前記（１）から（１３）のいずれかにおいて、前記横多重モードＳＡＷフィルタを２段縦属接続したことを特徴とする。

【００２１】（１５）本発明の横２重モードＳＡＷフィルタは、圧電体平板上に、少なくとも１個のすだれ状電極と、前記すだれ状電極が発生する弾性表面波をその両側において反射するための、１対の反射器を有した２個のＳＡＷ共振子を、前記弾性表面波の伝搬方向Ｘに対して相隣接してほぼ平行に配置した横２重モードＳＡＷフィルタにおいて、前記２個のＳＡＷ共振子が有する交差電極指幅ＷＣでもって形成されるすだれ状電極及び反射器領域の幅方向の外側に、空間長Ｇを隔てて、横１次対称モードＳ１の振動変位を漏洩させて減衰させるように構成した、同一極性のみからなる電極指群で形成される幅ＢＰのグレイティング状の電極領域を設けたことを特徴とする。

【００２２】（１６）前記（１）および（１０）において、前記空間長Ｇが弾性表面波の２波長から３波長であり、かつ前記グレイティング状の電極領域の幅ＢＰが３波長から４波長であることを特徴とする。

【００２３】（１７）前記（１５）において、前記グレイティング状の電極領域を形成する電極指群の端部を短絡して電流を供給する給電導体の内側が、前記弾性表面波の伝搬方向Ｘ軸方向にそってテーパ状の形状をなしたことを特徴とする。

【００２４】（１８）前記（１７）において、前記グレイティング状の電極領域を形成する電極指群の端部を短絡して電流を供給する給電導体の内側が、前記弾性表面波の伝搬方向Ｘ軸方向にそって２度から３度のテーパ状の形状をなしたことを特徴とする。

【００２５】

【発明の実施の形態】本発明に関して、具体的な実施例を説明する前に理論的な解説を行ない、本発明の理解を助けることにする。

【００２６】水晶、タンタル酸リチウム、ＰＺＴ、四ほう酸リチウム等の圧電体材料から平板を切り出して、その表面を鏡面研磨した後、レイリー型、ラム型、リーキー型、ＢＧＳ波等の弾性表面波の位相伝搬方向に対して直交して、例えば金属アルミニウムからなる多数の平行導体の電極指を周期的に配置したＩＤＴを形成し、さらには、その両側に一対の反射器を多数のストリップ導体を平行にかつ周期的に配置して構成し、１ポート型のＳＡＷ共振子を形成する。

【００２７】前記のＳＡＷ共振子において、前記ＩＤＴを構成する際の要点として、正電極と負電極を１対としてＭ対としたときに、ＩＤＴの電極指全体でのトータル反射係数Γを次式（１）の通り定義した上で、１０＞Γ

＞０．８とすれば、振動エネルギーが共振子の中央に集中した、いわゆるエネルギー閉込型ＳＡＷ共振子（参考文献：エネルギー閉じ込め弾性表面波共振子，信学技法ＵＳ８７－３６，ｐｐ９－１６（１９８７．９．））を実現できることが知られている。

【００２８】

【数１】

$$\Gamma = 4MbH/\lambda \qquad (1)$$

但し、ここでＭは前記ＩＤＴの対数、ｂは電極１本当たりの弾性表面波の反射係数、Ｈは前記導体の膜厚、λは弾性表面波の波長である。

【００２９】例えば、ＳＴカット水晶板で前記アルミニウム導体で形成されたＩＤＴであれば、ｂ＝０．２５５、Ｈ／λ＝０．０３としてＭ＝８０対とすれば、図１の１ポートＳＡＷ共振子を構成できる。このときΓ＝２．４４８程度となる。従って、Ｍ＝８０対程の１ポート型ＳＡＷ共振子を本発明の横２重モードＳＡＷフィルタに使用し、素子サイズの小型化をはかることが可能であると考えられる（発明が解決しようとする課題２））。

【００３０】さらに、本発明の横２重モードＳＡＷフィルタにおける発明が解決しようとする課題１）を解決す＊るに当たっては以下に述べる理論を用いて、いわゆる横モードとよばれるモードの振動変位とその共振周波数を算出し、フィルタの設計を行ったのでこの内容を順に説明する。前記横モードは、ＳＡＷ共振子の幅方向（弾性表面波の伝搬方向Ｘに対して直交するＹ軸方向のこと）の長さに依存して存在する固有振動モードであり、前記幅方向の長さとはＩＤＴのもつ電極指交差幅ＷＣを指すことが一般的である。この電極指交差幅ＷＣとは、正極性と負極性の電極指が相互に重なる配置となる幅方向の寸法である。

【００３１】次に、前記のＳＡＷ共振子の幅方向（Ｙ軸とする）について、ＳＡＷ共振子の振動変位を簡便に計算するための方法として、筆者等はすでにこれら横モードを支配する微分方程式を導いて公開している（高木，桃崎，他：”常温に動的及び静的零温度係数をもつＫカット水晶ＳＡＷ共振子”，電気学会　電子回路技術委員会　第２５回ＥＭシンポジウム，ｐｐ７９－８０，（１９９６））。あらためて、この方程式を記述すると式（２）となる。

【００３２】

【数２】

$$a\omega_o^2(Y)V(Y)_{,YY}+\{\omega^2-\omega_o^2(Y)\}V(Y)=0 \qquad (2)$$

ここで、ωは角周波数、ω_o（Ｙ）は該当する領域の素子角周波数、ａは幅方向の実効的せん断剛性定数、Ｖ（Ｙ）は幅方向の弾性表面波変位の振幅、Ｙは弾性表面波の波長で規格化したＹ座標である。また、ω_o（Ｙ）は座標Ｙにおける弾性表面波の速度を角周波数に換算した量であり、周波数ポテンシャル関数と呼ぶことにする。この周波数ポテンシャル関数はＳＡＷ共振子の動作点近傍においては、弾性表面波の伝搬路に存在するアルミニウム金属導体膜の厚みＨ（Ｙ）の関数により変化する。もっと一般的には、アルミニウム金属の質量ｍ（Ｙ）の関数で変化することが確認されている。従っ※て、ＳＡＷ共振子の主要部を構成するすだれ状電極部においては、すだれ状電極のもつ質量ｍ（Ｙ）によりω_o（Ｙ）はほぼ決定される。すなわち、ω_o（ｍ（Ｙ））である。前記の水晶ＳＴ－カットの場合には、膜厚みが薄いために、前記のω_o（Ｙ）はｍに対してほぼ比例して直線的に降下する。

【００３３】ここで計算を簡単にするために式（２）において、基準となる周波数ω_{oo}^2で割ると、

【００３４】

【数３】

$$aQ^2(Y)V(Y)_{,YY}+\{\Omega^2-Q^2(Y)\}V(Y)=0 \qquad (3)$$

ここで、$\Omega=\omega/\omega_{oo}$は規格化周波数、Ｑ（ｍ（Ｙ））はポテンシャル関数となる。

【００３５】変位振幅Ｖ（Ｙ）求める方法は、たとえ★ば、次の様に逐次積分にて計算することができる。

【００３６】

【数４】

$$V(Y,\Omega)=\int_0^Y V(Y)_{,Y}\,dY+c\ (\text{定数}) \qquad (4)$$

$$\text{ただし、}\quad V(Y,\Omega)_{,Y}=-\int_0^Y \{\Omega^2-Q^2(Y)\}V(Y)/aQ^2(Y)\,dY$$

式（４）のＶ（Ｙ，Ω）は規格化周波数の関数であるが、現実に起きる変位振幅は、エネルギーの最小原理である次式により与えられるΩにおいて得られる。

【００３７】

【数５】

$$\partial(2E(\Omega))/\partial\Omega=\int_{0}^{\infty}V^{2}(Y,\Omega)\,dY=0 \qquad (5)$$

以上の式（１）から（５）が本発明に用いた計算の基本式であり、これらを用いて、後述の具体的実施例になる横２重モードＳＡＷフィルタの設計を行い、試作品を製作して測定してみたので、これらを順に説明する。

【００３８】（実施例１）以下、本発明の実施の形態を図１から順を追って説明する。図１は本発明の横多重モードＳＡＷフィルタの一種である横２重モードＳＡＷフィルタに使用される電極パターンを、平面図で表した実施例１である。なお、１２６は＋Ｘ軸方向、前記＋Ｘに直交する軸は、＋Ｙ方向を示す。

【００３９】図１中の各部位の名称は、１００は圧電体平板、１０１は横２重モードＳＡＷフィルタのすだれ状電極の全体、すなわち全ＩＤＴ、１０２と１０３は各々、横２重モードＳＡＷフィルタの反射器１と反射器２である。前記全ＩＤＴ（１０１）の部分である、破線で囲まれた１０４は、ＳＡＷ共振子１（ＳＡＷＲ＃１）の入力ＩＤＴのみからなる領域であり、１０６はまた、ＳＡＷ共振子２（ＳＡＷＲ＃２）の出力ＩＤＴのみからなる領域である。さらに、破線で囲まれた１０５の領域は、前記１０４と１０６のＳＡＷ共振子１とＳＡＷ共振子２のＩＤＴが交差して存在する重複領域である。１０７は前記入力ＩＤＴの正極側の電極指の一つ、１０８は負極側の電極指の一つである（入出力信号は当然、高周波交流信号であるが、ここでは便宜上、一方を正極、他方を負極と呼んでいる。）。また、１０９は前記出力ＩＤＴの正極側の電極指の一つ、１１０は負極側の電極指の一つである。１１１と１１２は入力または出力の正極端子（パッド）である。１１３と１１４等のパターンは１１５と１１６，１１６と１１７等のパターン間を幅方向（Ｙ）に接続するためのものである。前記１１５と１１６，１１７は、前記２つのＳＡＷ共振子１の入力ＩＤＴとＳＡＷ共振子２の出力ＩＤＴの負極性側の電極指群の端部を接続する給電導体を共用して一体にパターン形成したものである。このように構成することで、給電導体は、弾性表面波の伝搬方向Ｘに直交する幅方向に折れる座標位置を複数とって矩形波状をなして形成されることになる。これによってＩＤＴの交差電極指幅が複数の寸法をとり、Ｘ方向にそって交互に変化することになる。そして、パターン１１５，１１７が第１のＹ座標Ｙ１をとり、パターン１１６が第2のＹ座標Ｙ２をとることになる。

【００４０】１１８は１１７と１１９と１２０のパッド間を接続するための導体パターン、１２３もパッド１２１と１２２間を接続するための導体パターンである。１１９と１２０、１２１、１２２は前記入出力ＩＤＴの負極側の電位を与えるパッドである。１２４と１２５等は反射器２の導体ストリップであって、弾性表面波を反射する役目を果たす。前記１２４と１２５はこの場合において、相互に接続されていないが、接続された場合であってもかまわない。１２７の矢印の領域は、２つの反射器１と反射器２の一部と全ＩＤＴ１０１の部分から成り、全体でＳＡＷ共振子１を構成する。また１２９の矢印の領域は、２つの反射器１と反射器２の一部と全ＩＤＴ１０１の部分から成り、全体でＳＡＷ共振子２を構成する。さらに１２８の矢印の領域は、前記ＳＡＷ共振子１とＳＡＷ共振子２のＩＤＴが交差する重複領域を示す。

【００４１】１００の圧電体平板は、水晶、タンタル酸リチウム、四ほう酸リチウム等の圧電性を有する単結晶およびＺｎＯ等の圧電性薄膜を形成した基板等からなる。前記の１００上に形成された前記の２個のＳＡＷ共振子１２７、１２８、１２９を構成するＩＤＴならびに反射器等は、アルミニウムおよび金等の導電性を有する金属膜を蒸着、スパッタ等の手段により薄膜形成した後、フォトリソグラフィ技術によりパターン形成して作られる。前記ＩＤＴと反射器の電極指群は、利用する弾性表面波（レーリー波及びリーキー波等）の位相進行方向（長手方向＋Ｘ）に対して直交して、平行かつ周期的に多数配置される。一実施例として図示した１０２と１０３の反射器は、振動モードを選択的に励起するための電極パターンを形成したものであり、一例として基本波対称モードＳ０用である。

【００４２】（実施例２）次に図２は、前述の図１の横２重モードＳＡＷフィルタを２段縦属接続した一実施例である。図中の各部位の名称は、２００が圧電体平板、細かい破線で囲まれた２０１は第１の横２重モードＳＡＷフィルタ（ＳＡＷＦ＃１）、２０２は第２の横２重モードＳＡＷフィルタ（ＳＡＷＦ＃２）である。２０５と２０６、２０７、２０８は、入力または出力端側の負極電位を与えるパッド、２０３と２０４は、入力または出力端子側の正極電位を与えるパッドである。また、２１０と２１１は、第１と第２の横２重モードＳＡＷフィルタ２０１、２０２間の負極間を接続する導体パターンである。さらに、２０９は第１と第２の横２重モードＳＡＷフィルタ２０１、２０２間の正極間を接続する導体パターンである。

【００４３】つぎに、本発明の図１と図２に用いられている全ＩＤＴ（図１の１０１）の構成につき図３を用いて詳細な説明を行う。図中の破線で囲まれた３００は、前記図１の１０１の一部に対応している。前記３００の全体は、細かい破線で囲まれた５つの領域の合成からなり、それらは３０１のＩＤＴ１、３０４のＩＤＴ２、３１５のＩＤＴ１２、２つの結合領域３０２と３０３とからなる。ＩＤＴ１の負極の電極指の一つである３１０

は、第１の給電導体パターン３０８に接続し、さらに３０９の幅方向（Ｙ軸方向）に横断するクロスバスバーを介して第２の負極性側給電導体３０７に接続している。前記３０９の幅方向（Ｙ軸方向）に横断するクロスバスバー部位（図１の１１３，１１４に相当）のＸ方向の寸法は、スプリアス共振を発生させない寸法である、１／４λ（λは弾性表面波の波長）の奇数倍の値をとる。ついでながら、図１の１２３と１１８および図２の２１０と２１１も同様な理由から１／４λ（λは弾性表面波の波長）の奇数倍の値をとる。領域３０２と３１５と３０３全体で、図１の１２８の重複領域をカバーする。３０５は入力ＩＤＴ（ＩＤＴ１）の正極性側の給電導体、３０６は出力ＩＤＴ（ＩＤＴ２）の正極性側給電導体であ＊る。各部位の幅寸法は、３０１がWC_1、３０２がG_1、３１５がWC_{12}、３０３がG_2、３０４がWC_2である。また同図の中央に配置した階段状特性３１２で表される特性図は、前記ＩＤＴの各領域がもつ規格化周波数ポテンシャル関数ＰＹＭ（Ｙ）を示すものである。前記ＰＹＭ（Ｙ）はＩＤＴのＸ軸方向全体にわたって平均して得られたものである点に注意を要する。これが可能な理由は、反射器間にて無限回の弾性表面波の反射が繰り返される共振子を扱っているからである。前記作用のところで説明した式（３）中のＱ（Ｙ）とＰＹＭ（Ｙ）の関係は次式で与えられる。

【００４４】

【数６】

$$Q(Y)=\omega_{00}\{1/\eta+(1-1/\eta)\,PYM(Y)\} \qquad (6)$$

ただし、これから具体的に説明する３０から４５度回転Ｙ板である水晶ＳＴカットＸ伝搬基板においては、ηとして０．９９から０．９５の値をとる。この条件下で、前記規格化周波数ポテンシャル関数ＰＹＭ（Ｙ）がどのようにして与えられたかについて、次に説明する。まず最初にWC_1とWC_2、WC_{12}で表される電極指の周期的配列で構成された領域は、電極指のつくる周期的格子構造により弾性表面波が摂動を受け、自由表面の伝搬速度ＶｓからＶｍに速度が低下する。従ってＶｍに対応して前述の領域の角周波数ω_{00}（＝２πＶｍ／（２ＰＴ））が決定されている。ＰＴは電極指の配列周期長である。この角周波数に対応するＰＹＭが１であることは式（６）から容易に理解できる。また、自由表面に対するＰＹＭはＰＹＭ＝０であり、この場合の角周波数はω_{00}（１／η）（　＞ω_{00}）となる。図３中のＢＢで示される給電導体部は、全面被覆としてＦＥＭ解析で得られる弾性表面波速度から、前記の自由表面の速度Ｖｓより５００から１０００ｐｐｍとやや小さいものとされている。従って、ＰＹＭ＝０．１程度に対応する（０．００１＝１／０．９９－１）×ＰＹＭ）。領域Ａは、領域WC_1の電極指本数の１／４が弾性表面波の伝搬路と交差しているから、約０．２５の速度降下とみなす。従ってＰＹＭ＝０．２５である。最後に領域G_1とG_2で表される結合領域のＰＹＭについては、まずｄ部は伝搬路の電極指の平均本数が電極指群（３１０と３１１）が存在する領域と３０７の給電導体が存在する領域が、Ｘ軸方向に周期的に配置されているから、ＰＹＭ＝（１＋０．１）／２＝０．５５となる。またｂ部は同様に考えて、ＰＹＭ＝（１＋０．２５）／２＝０．６２である。以上の規格化周波数ポテンシャル関数ＰＹＭ（Ｙ）によって発生する横モードの変位Ｖ（Ｙ）は、図３の最下部に図示した３１３のＳ０モード（基本波対称モード）と３１４のＡ０モード（基本波斜対称モード）である。

【００４５】つぎに、本発明の構成により得られる特性につき図４から図１０を用いて説明する。前記の特性は、水晶ＳＴカット（３０から４５度の回転Ｙカット）Ｘ伝搬方位についての具体的設計例である。最初に図１０において、ＳＡＷ共振子の等価定数とＩＤＴ対数の関係を示す。前記ＳＡＷ共振子の周波数として２５０ＭＨｚ　とした。前記周波数にて、水晶で製作可能と思われる最小の素子サイズである約２×３ｍｍに収納するためには、ＩＤＴの対数Ｍと片側の反射器Ｎの和が２００以内である必要がある。この条件のもとに、１個のＳＡＷ共振子のＱ値（共振先鋭度）（曲線１０００）と等価直列共振抵抗R_1（曲線１００１）の特性を図１０に示した。ＩＤＴの対数Ｍが４０から１２０の範囲において、約１万以上のＱ値が、また、Ｒ１はＭが６０から１２０対の範囲において１００Ω程度が得られる。ただし、１個のＳＡＷ共振子の電極指交差幅（WC_T／２、ここで$WC_T=WC_1+G_1+WC_{12}+G_2+WC_2$）として、８±１波長を用いた。本発明には、前記の電極指交差幅の２倍が、図３の全ＩＤＴ幅WC_T（$=WC_1+G_1+WC_{12}+G_2+WC_2$）と等しくとる。従って前記全ＩＤＴ幅が１４から１８波長でかつ、対数Ｍ６０から１２０対、従って反射器の導体本数は１４０から８０本とすれば、本発明の目的とする特性が得られる。

【００４６】つぎに、図４と図５は本発明の横２重モードＳＡＷフィルタが有する固有振動モードＳ０とＡ０の周波数と図３中の寸法WC_{12}との関係を示す特性である。図中、横軸はWC_{12}を動作状態での弾性表面波の波長単位λで、縦軸は周波数変化率Δｆ／ｆであり、ｐｐｍ単位（10^{-6}）で表した。図中の０ｐｐｍは、ＳＡＷ共振子の電極指交差幅が無限大の共振周波数に対応する状態である。まず図４の曲線４００はＳ０モードの共振周波数である。図示の通り、共振周波数は点ＱのWC_{12}＝０の８００ｐｐｍから、WC_{12}が増大するに従い点Ｐの値である３６０ｐｐｍ（４０１）に向かって減少している。この現象の詳しい解釈については、図８と図９を用いて後述する。一方、図５はＡ０モードの共振周波数（５００）である。WC_{12}により、大きくは変化してないことがわかる。この現象は、Ａ０モードの共振周波数が前記WC_Tにより決定されることから理解できる。図

４と図５からＳ０とＡ０モードの共振周波数差がおよそ１０００ｐｐｍであれば、目的のＰＨＳとかＧＳＭ用途のＩＦフィルタが実現できるから、WC_{12}＝２λ以上で良いことになる。WC_{12}の上限値は、ＳＡW共振子１と２から決定されるフィルタインピーダンスが４００から５００Ωとすることから決まり、５波長以下であればよかった。ちなみに、図３中の寸法G_1とG_2は１波長程度を用いた。

【００４７】つぎに、図６は本発明の横２重モードＳＡWフィルタの入力端子側（図１の１１１）からみたS_{11}反射特性である。図６の横軸は周波数変化率、縦軸はS_{11}の値の相対値である。S_{11}の値がピークをとる周波数が、低い側から基本波対称モードＳ０と基本波斜対称モードＡ０である。Ｓ０とＡ０間の周波数差は１０８０ｐｐｍとなっている。さらに、図７は図１のフィルタの伝送特性であり、縦軸のＳｂは挿入損失の振幅特性である。Ｓｂのもつ３ｄＢ通過帯域幅はおよそ１５００ｐｐｍとなっており、これを図２の２段縦属接続の場合においては、およそ１０００ｐｐｍの通過帯域幅となった。ただし、通過地域が傾斜しているが、これは、前記Ｓ０とＡ０モードの共振振幅が異なることによって発生する。

【００４８】次に、図２の本発明の構造を用いると通過帯域幅が広がることにつき、図８と図９をもちいて解説を行う。図８は、図４のＰ点に対応する一様な構造をとるＩＤＴについて、規格化周波数ポテンシャル関数ＰＹＭ（Ｙ）とＳ０モードの変位Ｖ（Ｙ）の関係を示している。図中の破線で囲まれたＩＤＴ８００は、正負電極指群とこれを接続する給電導体８０５と８０４からなる。前記ＩＤＴがつくる周波数ポテンシャル関数ＰＹＭ（Ｙ）は、図８の下部の特性８０９であり、図上段のＩＤＴに対応している。前記ＩＤＴの電極指交差部位は一様に＋Ｘ軸方向に配置されているため、この部分において８０９の周波数ポテンシャル値はＰＹＭ＝１と一定となる。この状態にて得られるＳ０モード変位Ｖ（Ｙ）は、中段の曲線８０６のようになめらかな中トツな関数となっている。この場合のＹ軸方向の弾性表面波の波数ｋは相対的に小さく、従って近似的に$\Delta f/f = a' k^2$の関係にあるＳ０モードの共振周波数は相対的に小さい値となる（図４中のＰ点）。ただし、前記ａ’は前述の式（２）中のａに比例する。つぎに、図４中のＱ点に対応する構成が図９である。９００の破線に囲まれたＩＤＴは、２つのＳＡW共振子のＩＤＴ部を結合した状態であり、正極性の給電導体９０５と電極指９０１と９１１等が第一のＳＡW共振子のＩＤＴであり、正極性の給電導体９０４と電極指９０２と９０４等で第２のＳＡW共振子のＩＤＴである。負極性の給電導体９０６は一体に形成され共用されている。前記の結合したＩＤＴのもつ周波数ポテンシャル関数ＰＹＭ（Ｙ）は、今度は下段にある階段関数９０９となる。負極性の給電導体９０６の近傍の周波数ポテンシャル関数、は図３と同様な理由により下段のｂ，ｄ領域のように与えられる。この場合に与えられるＳ０モードの変位関数Ｖ（Ｙ）は、中段の９０７のように２つの幅の小さいＳ０モードが中央１波長（２ｂ＋ｄ）において結合した変位状態をとる。従ってＹ軸方向（９０８）に伝搬する弾性表面波の波数ｋは相対的に大きな値となり、前述と同様な$\Delta f/f = a' k^2$の関係から共振周波数は相対的に大きくなる。以上が図３のＱ点がＰ点より大きな理由である。

【００４９】さて、以上に基づき試作してみると、発明が解決しようとする課題２）の小型化に際して、課題の１）である、フィルタの通過帯域幅の広帯域化を実現することができた。その一方で、更に検討を行った結果、改善が望まれる幾つかの課題が存在することが判明した。これらを列挙すると、ａ）フィルタを構成する基本波斜対称モードＡ０のＱ値低下。ｂ）高次インハーモニックモードを原因とするスプリアスの発生。Ｃ）フィルタ特性において、帯域外減衰量の増加（４０ｄＢ）であった。まず、これらの原因と対策を概観してみる。

【００５０】まず、前述のａ）の原因を究明した結果、原因はＩＤＴの電極指上に発生する正負電荷が短絡して発生するジュール熱により、フィルタを構成する共振子のＱ値を低下させたことにあった。Ｑ値の程度は、前記のＳ０モードが８０００～１００００、Ａ０モードが約４０００である（各モードは図６参照）。

【００５１】前記Ａ０モードのみがＱ値低下となった理由は、図３の重複領域である３１５の電極指領域において前記Ａ０モードが図３の３１４の変位状態をとる結果、変位に比例した電荷が電極指上に発生し、短絡電流が流れることによって内部のエネルギー損失が発生したことにある。これに対してＳ０モード（図３の３１３）は、重複領域３１５において同極性であり、短絡電流は流れず内部損失を発生しない。従ってこの対策は、前記Ｓ０とＡ０モードに対して、可能な限り発生電荷の短絡現象を生じないようにすることである。また、Ｓ０とＡ０モードの共振振幅を同一として、フィルタの通過帯域特性を平坦化するためには、前記モードの電極面積を同一にして、集積電荷総量を等価にすることが必要である。

【００５２】つぎに、ｂ）の原因を究明した結果はつぎの通りである。本発明の横２重モードＳＡWフィルタの挿入損失を３、４ｄＢ程度とするためには、構成する各モードのＱ値を１２０００程度にすることが望ましい。そこで、反射器及びＩＤＴにおける各電極指の反射係数を増加させる目的で、電極膜厚みを増加することが知られているが、これを行った際に、スプリアスである横１次対称モードＳ１のレベルが増大した。また、図１の１１５、１１６、１１７等に示される負極側（接地）の給電導体の形状によっては、縦基本波斜対称モードＬＡ０が発生する。これらスプリアスに対する対策としては、

モードＬＡ０に関しては、前記給電導体によって形成される電極指交差幅WC(X)をフィルタの長手方向Ｘの中央に関して線対称とすることである。またモードＳ１に関しては、パワーフローベクトルに関する事実を応用して前記Ｓ１モードを抑圧する方策を考案した。

【００５３】つぎに、前記Ｃ）の原因究明をした結果、入力側のＩＤＴと出力側のＩＤＴの電極指群が相互に重なる部位が存在し、これによって部分的にトランスバーサルフィルタを形成して、入力側から出力側に共振現象に寄与しない弾性波がリークする結果、帯域外減衰量が４０ｄＢ程度に悪化するためである。従ってこの対策は、ＩＤＴの励振領域が重ならないようにすることである。以上簡単に問題を説明したが、以下に具体的実施例を上げて、さらに詳細な説明を行う。

【００５４】まず最初、図１１は、縦基本波斜対称スプリアスモードＬＡ０を抑圧するためと、入力側と出力側の端子対間を電気的に絶縁するための構成をとった本発明の横２重モードＳＡＷフィルタの他の実施例である。図１１は、図２と同様に２ポール型のＳＡＷフィルタを２段従属接続したものである。図中の各部位の名称は、１１００は水晶等からなる圧電体平板、１１０１と１１０２は各々第１と第２のＳＡＷフィルタ、１１０３は入力側と出力側を合わせたＩＤＴ全体、１０４と１０５は共通の反射器、１１０６は第１のＳＡＷフィルタの正極側入力端子、１１０７は負極側の入力端子、１１０８と１１０９は第１のＳＡＷフィルタの出力側の負極側の端子、１１１３は正極側端子、１１１０と１１１１は図１で一体であった負極側の給電導体をその中央で狭間隙でもって２つに分割したものである。また、１１１４はＹ軸、１１１５はＸ軸である。第２のＳＡＷフィルタ１１０２は第１と同一のため説明を省略する。図１１の要点は、前述の負極側の給電導体が２つに分割していることと、ＩＤＴの有する電極指交差幅WC(X)が前記のＸ軸方向の中央線（Ｙ軸１１１４に相当する）に関して線対称であることである。これについては、図１２にさらに詳述した。図１２中の横軸１２０３は、図１１のＸ軸と同一である。縦軸は入力側のＩＤＴがもつ電極指交差幅WC(X)（１２０２）の相対値である。階段状の関数１２００が本発明の縦基本波斜対称モードＬＡ０からなるスプリアスが発生しない場合であり、１２０１は前記ＬＡ０モードからなるスプリアスが発生する場合である。関数１２００はＩＤＴの全長Ｘを４つに等分して、偶数回（この場合２回）のＷＣ変化点を有している。前記縦モードスプリアスＬＡ０は、図１６の本発明によるフィルタ伝送特性図中の１６０１で示されるものである。

【００５５】つぎに図１３は、本発明の横２重モードＳＡＷフィルタを構成するＳ０とＡ０モードの共振先鋭度、即ちQ_AとQ_S値を向上しかつ等価とするための電極パターンの一実施例であって全体の半分を示した。図中の１３０１は幅寸法の中央に配置したＸ軸、１３０２はＹ軸である。１３０３、１３０４の領域は、電極指１３１０等を１３０１のＸ軸に近接して右手前にて、細いスペースにて分割している部位である。同様に領域１３０５にても、正極性側に接続した電極指１３０９は分離されている。従って分離した電極指部位１３１２は、正極１３０９に接続した状態より、分離している分だけ前記Ａ０モードの正電荷を短絡せずエネルギー損失を軽減できる。薄く塗った領域１３０５と１３０６は、各々入力側と出力側のＩＤＴの有効な電極指交差幅ＷＣＡ(X)が形成する総面積であり（特にＷＣでなくＷＣＡと特記した）、１３０５と１３０６は面積が等しい。このようにすることにより、前記Ｓ０とＡＯの集積する総電荷量が等しくなり、フィルタの通過特性が平坦となる。また図１３の１３０３と１３０５の配置構成をとれば、入力と出力側ＩＤＴの電極指交差幅ＷＣＡが重なることがないため、図１６の１６０４の帯域外減衰量は－４０ｄＢから－６０ｄＢ近くに減少する。

【００５６】次に図１４に前記Ｓ１モードスプリアス（図１６の１６０２の点線）を抑圧するための構成を示す。図中の１４００はＸ軸、１４０１はＹ軸。破線内１４０２は本発明のグレイティング状の電極領域からなる、前記Ｓ１モードの変位を漏洩させるための領域であり、これはＩＤＴの電極指領域１４１１の左に空間長Ｇを隔てて最大幅ＢＰにわたって、ＩＤＴ１４１１と同一の電極周期長（弾性表面波の波長λ＝２ＰＴとほぼ同一）を有する電極指群にて構成されている。前記の幅ＢＰはＸ軸方向にテーパ形状をなして変化する寸法を持たせることができる。１４０３は前記電極指群の端部を短絡するための給電導体、１４０４と１４０５等は電極指、１４０６のδは前記Ｘ軸１４００方向と、１４０３の内側端部の線との成す角でチルト角と呼ぶ。１４０７は反射器であり、反射器の左端部は、前記グレイティング状電極領域の右端部にほぼ一致する。同図中段の１４０８（破線）は、前記１４０２のグレイティング状電極指群領域が存在しない場合の、前記Ｓ１モードの変位状態Ｖ（Ｙ）と、前記グレイティング状電極領域が存在する場合の前記Ｓ１モードの変位状態Ｖ'（Ｙ）１４０９（実線）を図示したものである。さらに、同図下段の階段状の関数１４０１は、図１４のＩＤＴ部位のＹ軸上の領域が有する平均的周波数ポテンシャル関数ＰＹＭ（Ｙ）を図示したものである。

【００５７】つぎに、図１４の構成によって前記Ｓ１モードが抑圧される様子を図１５、図１７を用いて説明することができる。まず図１５は前記図１４の構成が有する各振動モードである横基本波対称モードＳ０（１５０１）、横基本波斜対称モードＡ０（１５０２）、横１次対称モードＳ１（１５０３）が示す、前記幅ＢＰを変化させた場合の周波数変化（Δｆ／ｆ（ｐｐｍ））の様子である。これら特性は、前述の理論式（４）、（５）によって計算したものである。図１５で見られるように、

前記Ｓ０とＡ０モードは前記幅ＢＰを変化させてもほとんど変化しない。一方前記Ｓ１モードは空間長Ｇをパラメータとして、ＢＰが２λ以上において、周波数の降下現象が発生している。この現象は空間長Ｇが小さい程、周波数降下現象が始まるＢＰ寸法が小さくなる。これは、Ｇが小さい程Ｓ１モードの変位が外側１４０２の領域にリークし、振動変位が１４０９のように広がる結果、Ｙ軸方向の波数ｋが減少し周波数が降下することを示している。前記図１４の１４０２領域にリークした振動エネルギーは弾性表面波としてＸ軸方向に伝搬するが、反射器１４０７がカバーする領域からはずれるため、反射されずにリークし失われる結果、Ｓ１モードのＱ値は減少する。このようにしてＳ１モードの抑圧が行われる。前記ＢＰとＧ寸法範囲としては、できるだけＢＰ寸法を小さくすることが素子の小型化に望ましい点と、Ｓ０及びＡ０モードの振動が損なわれないことを考えて、Ｇの範囲を２波長（λ）から３波長範囲、ＢＰの範囲が３波長から４波長範囲が良い。また前記チルト角δは、本来圧電体平板が有する弾性表面波エネルギーの最大伝搬方向を示すパワーフロー角に対するズレ角であって、図１７に前記チルト角δに対する１個のＳＡＷ共振子が示すＱ値の関係を示した。図中横軸はチルト角（度）、縦軸はＱ値である。チルト角δが２～３程度であれば、δ＝０に対してＱ値を半減できる。この効果は振動変位がチルト角を有する給電導体（図１４の１４０３）に達する前記Ｓ１モードのみに有効である。以上のＳ１モード抑圧対策を施した結果、本発明の横２重モードＳＡＷフィルタにおける前記Ｓ１モードの抑圧効果は、従来の－２０ｄＢから－４０ｄＢ程度に抑圧可能である。図１６の１６０２と１６０３にその様子を示した。

【００５８】以上、本発明の横２重モードＳＡＷフィルタの構成および特性につき説明した。構成例は水晶ＳＴカットで示したが、他のカットである１６度回転Ｙ板であるＬＳＴカットとか、９．６度回転Ｙ板であるＫカットでもよく、さらにまた水晶以外の圧電気材料であっても適合できることをつけくわえる。

【００５９】

【発明の効果】以上述べたように本発明によれば、例えば水晶基板を用いて横２重モードＳＡＷフィルタの小型化をはかるに際して、前記ＳＡＷフィルタを構成する２つのＳＡＷ共振子のＩＤＴを一体化する場合に、共用する負極性側の給電導体を、素子の幅方向Ｙに対して２つ以上の複数位置をとって弾性表面波の伝搬方向Ｘに交互に周期的に繰り返すことにより、フィルタの特性を合成する２つの独立な共振モードである基本波対称モードＳ０、基本波斜対称モードＡ０間の周波数差を従来より大幅に広げることができるため、横２重モードＳＡＷフィルタの通過帯域幅を３０％広げることができ、ＰＨＳ等のチャンネル間の周波数幅が大きい通信装置用途の中間周波フィルタを市場に提供できる。さらにまた、ＩＤＴの対数Ｍを６０から１２０対と少なく設計することにより、従来と比較して素子平面積が半分と小型で良好な前記フィルタが実現できる。またこの際に、電極膜厚みとか幅寸法を増加させせることによって発生する縦横の高次モードスプリアスを、ＩＤＴ交差幅の対称性とか、振動変位をリークさせるグレイティング状の電極領域を構成することによって抑圧できるため、フィルタの帯域外減衰量に優れた前記フィルタが実現でき、特性が優れて小型な通信装置の実現に寄与できる。

【図面の簡単な説明】

【図１】　本発明の横２重モードＳＡＷフィルタの一実施例が有する導体パターンを示す平面図。

【図２】　本発明の２段縦属接続をした横２重モードＳＡＷフィルタの一実施例が示す図。

【図３】　本発明の横２重モードＳＡＷフィルタのＩＤＴの一実施例が示す平面図。

【図４】　本発明の図１が示す特性図。

【図５】　本発明の図１が示す他の特性図。

【図６】　本発明の図１が示す他の特性図。

【図７】　本発明の図１が示す特性図。

【図８】　従来一様構造のＩＤＴに関する概説図。

【図９】　従来の横２重モードＳＡＷフィルタのＩＤＴに関する概説図。

【図１０】　本発明の構成要素であるＳＡＷ共振子の特性図。

【図１１】　基本波縦斜対称スプリアスモードＬＡ０を抑圧することを目的とした、本発明の横２重モードＳＡＷフィルタの他の実施例が有する導体パターンを示す平面図。

【図１２】　本発明の図１１が有する電極指交差幅ＷＣを示す図。

【図１３】　本発明の横２重モードＳＡＷフィルタのＩＤＴが示す導体パターンの一実施例が示す平面図。

【図１４】　横高次スプリアス抑圧を目的とした、本発明の横２重モードＳＡＷフィルタの他の実施例が有する導体パターンを示す平面図。

【図１５】　本発明の図１４が示す特性図。

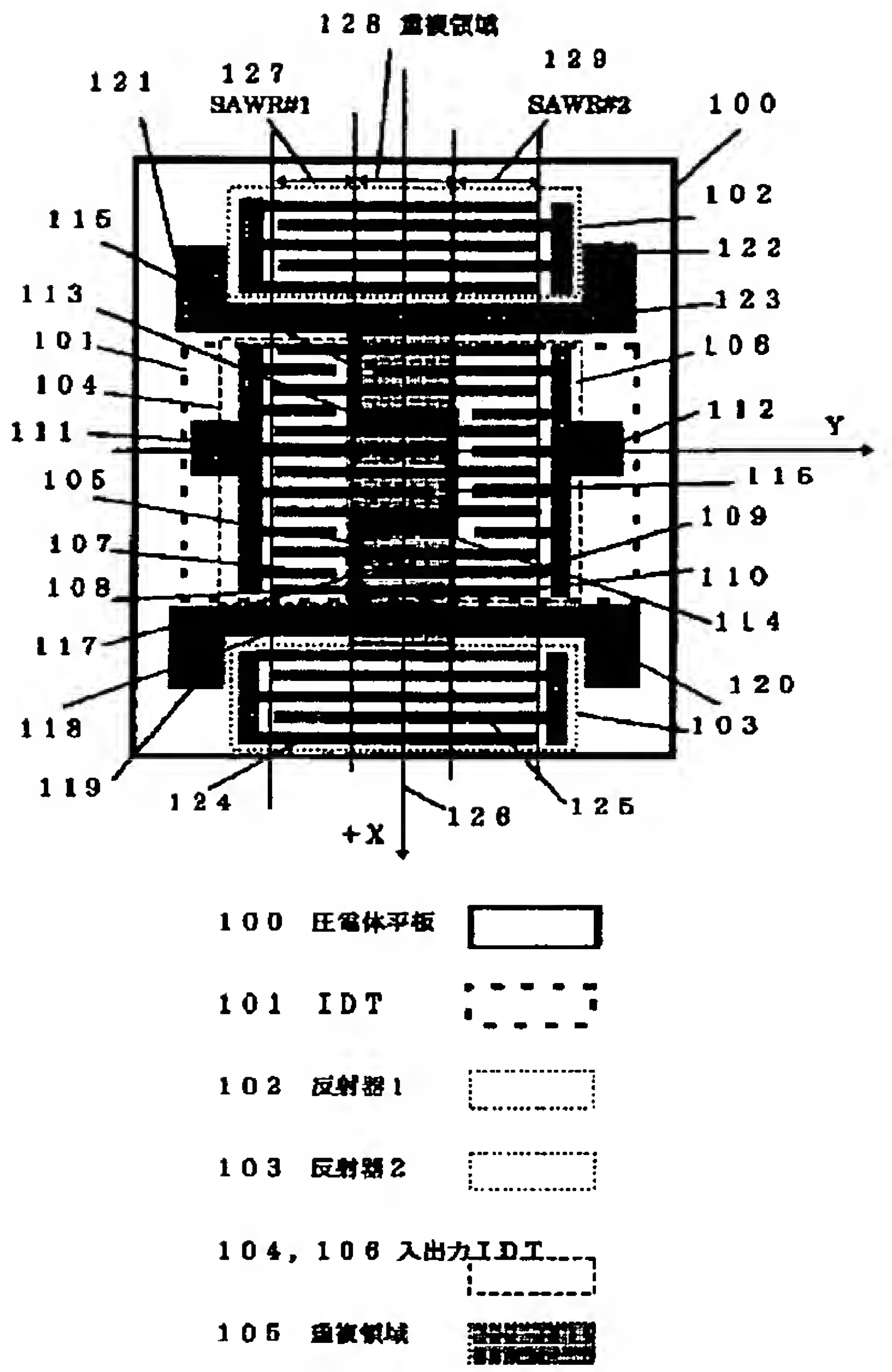
【図１６】　本発明の図１１及び図１４が示すフィルタの伝送特性図。

【図１７】　本発明の図１４が示す共振子のＱ値特性図。

【符号の説明】

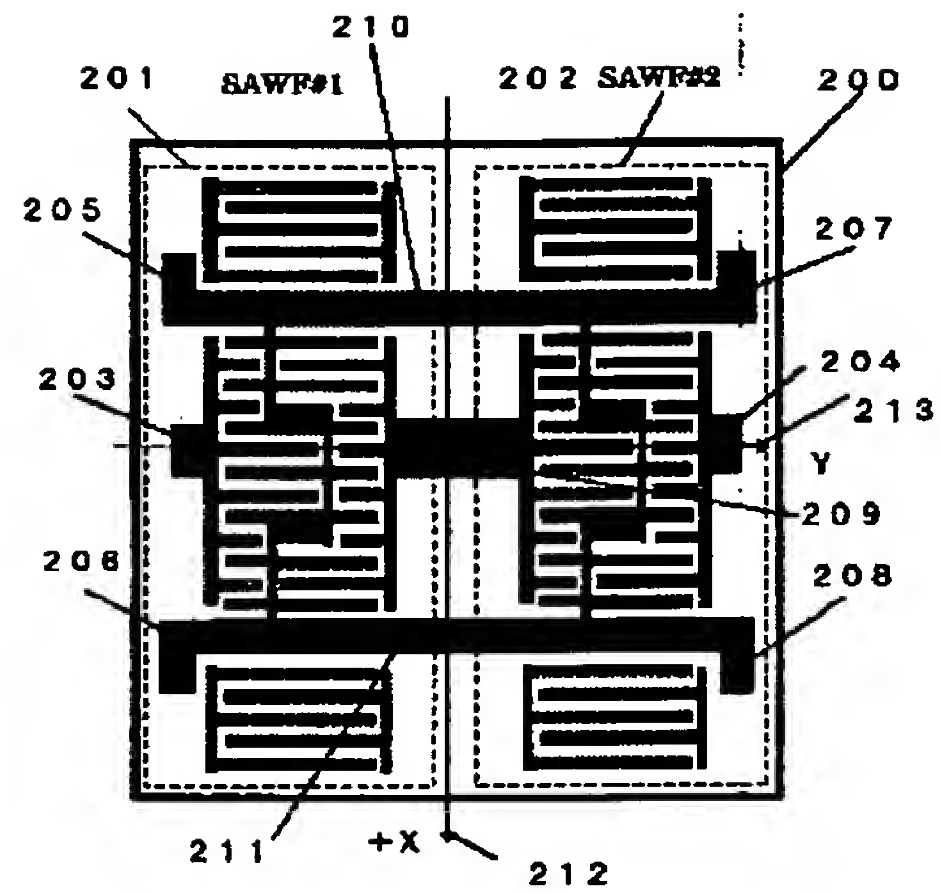
１００　圧電体平板
１０１　ＩＤＴ
１０２　反射器１
１０３　反射器２
１０４，１０６　入力および出力ＩＤＴ
１０５　重複領域

【図１】



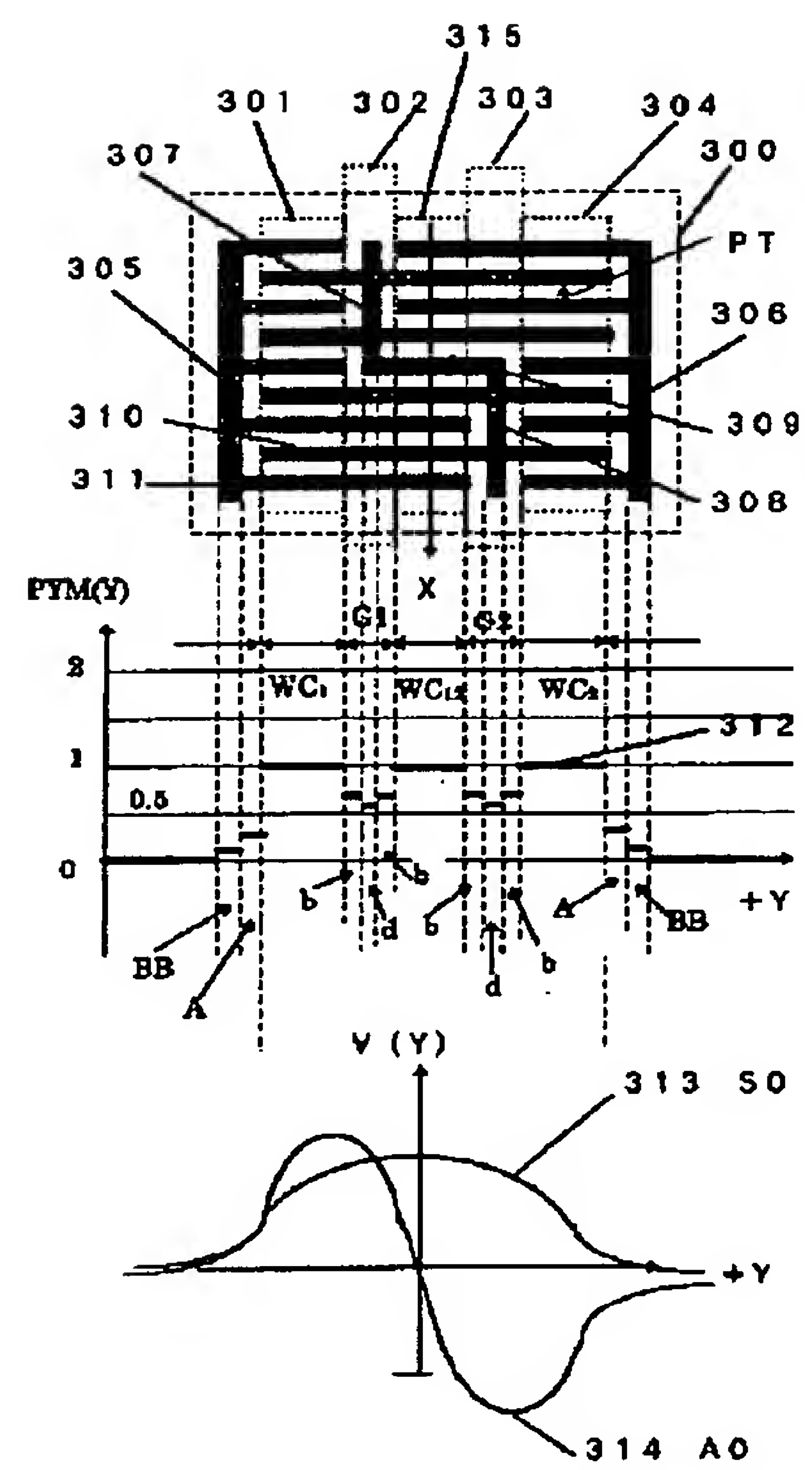
１２８ 重複領域
１２１
１２７ SAWR#1
１２９ SAWR#2
１００
１０２
１１５
１２２
１２３
１１３
１０１
１０６
１０４
１１２
１１１
Y
１０５
１１６
１０９
１０７
１１０
１０８
１１４
１１７
１２０
１１８
１０３
１１９
１２４
１２６
１２５
+X
１００ 圧電体平板
１０１ IDT
１０２ 反射器１
１０３ 反射器２
１０４，１０６ 入出力IDT
１０５ 重複領域

【図２】



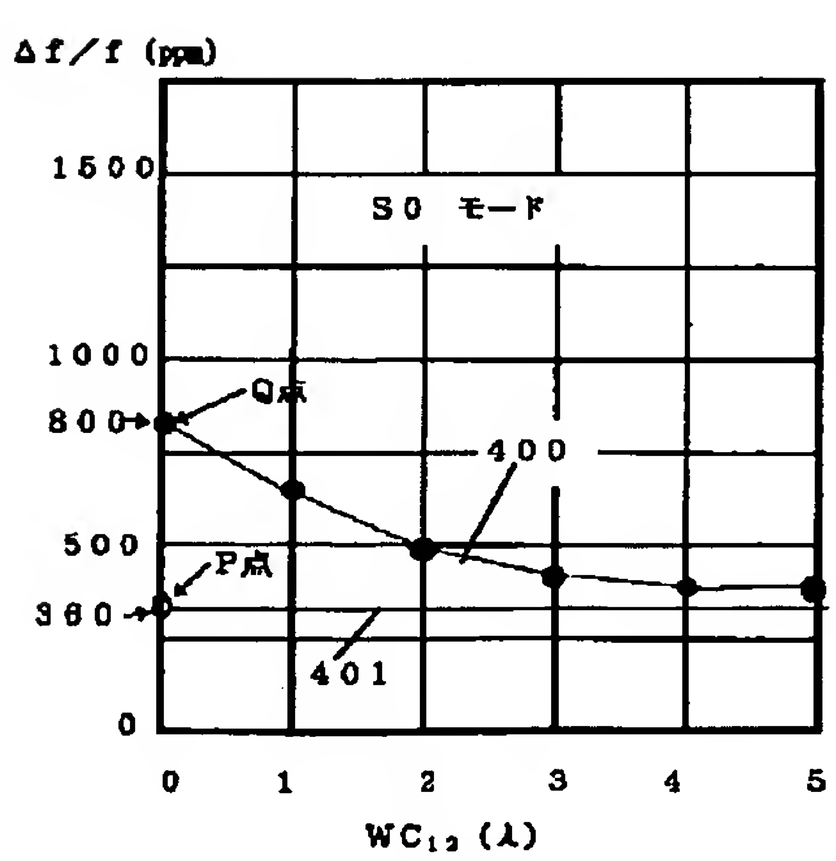
２１０
２０１ SAWF#1
２０２ SAWF#2
２００
２０５
２０７
２０３
２０４
２１３
Y
２０９
２０６
２０８
２１１
+X
２１２

【図３】



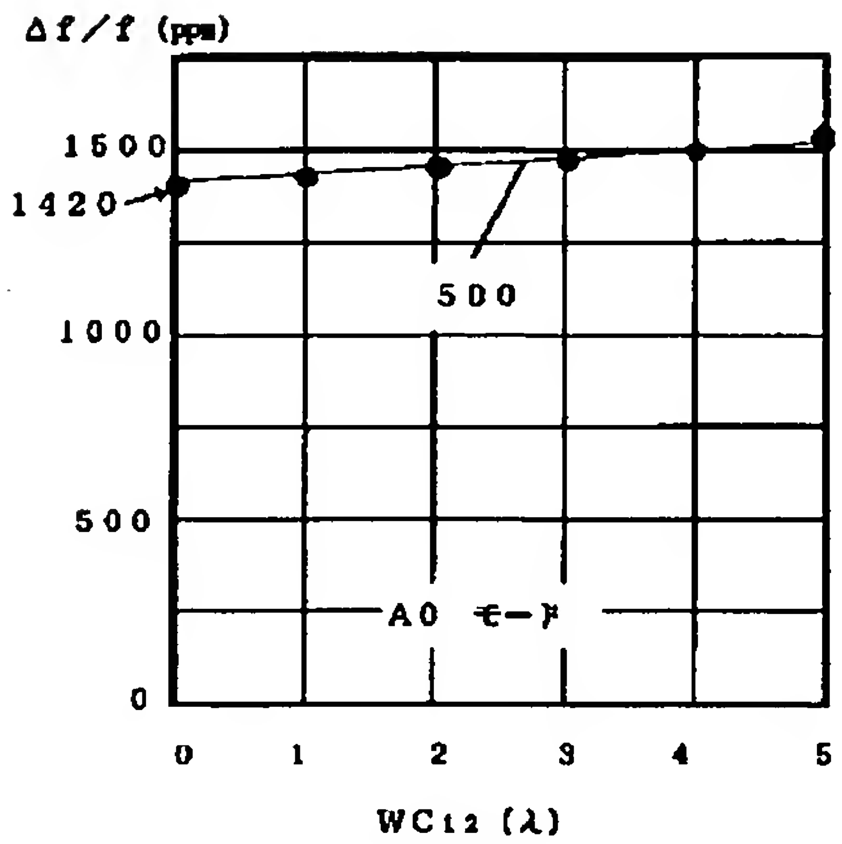
３１５
３０１
３０２
３０３
３０４
３０７
３００
ＰＴ
３０５
３０６
３１０
３０９
３１１
３０８
X
PYM(Y)
G1
G2
WC1
WC12
WC2
３１２
2
1
0.5
0
BB
A
b
d
+Y
V (Y)
３１３ S0
+Y
３１４ A0

【図４】

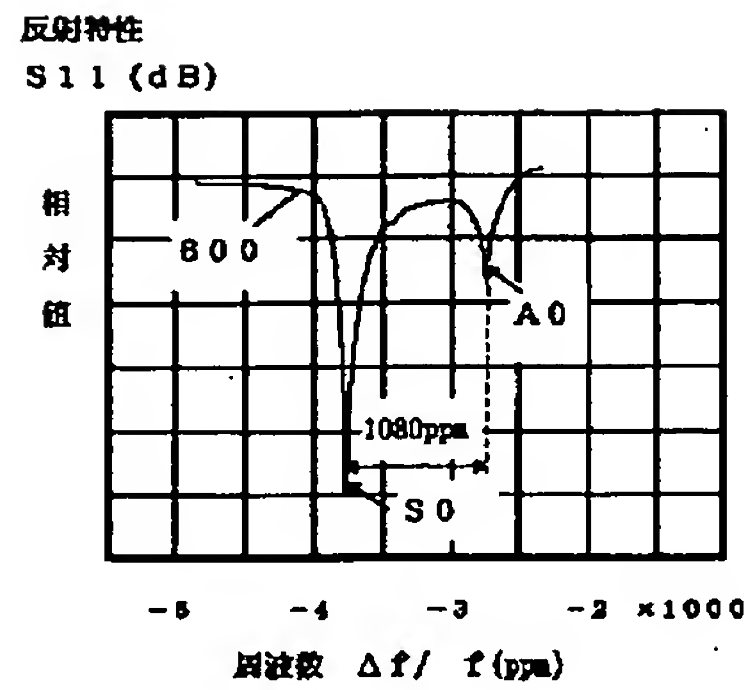


Δf/f (ppm)
１５００
S0 モード
１０００
８００
Q点
４００
５００
P点
３６０
４０１
0
0
1
2
3
4
5
WC12 (λ)

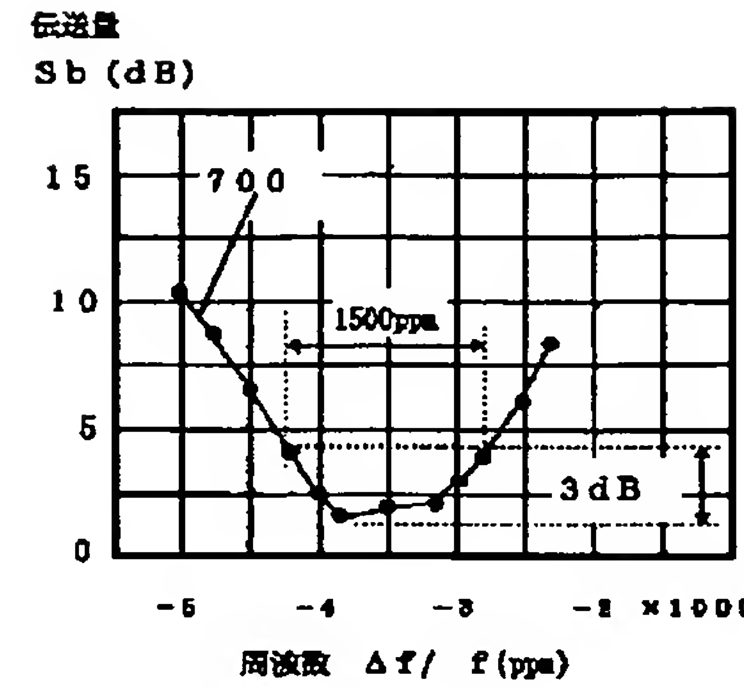
【図５】



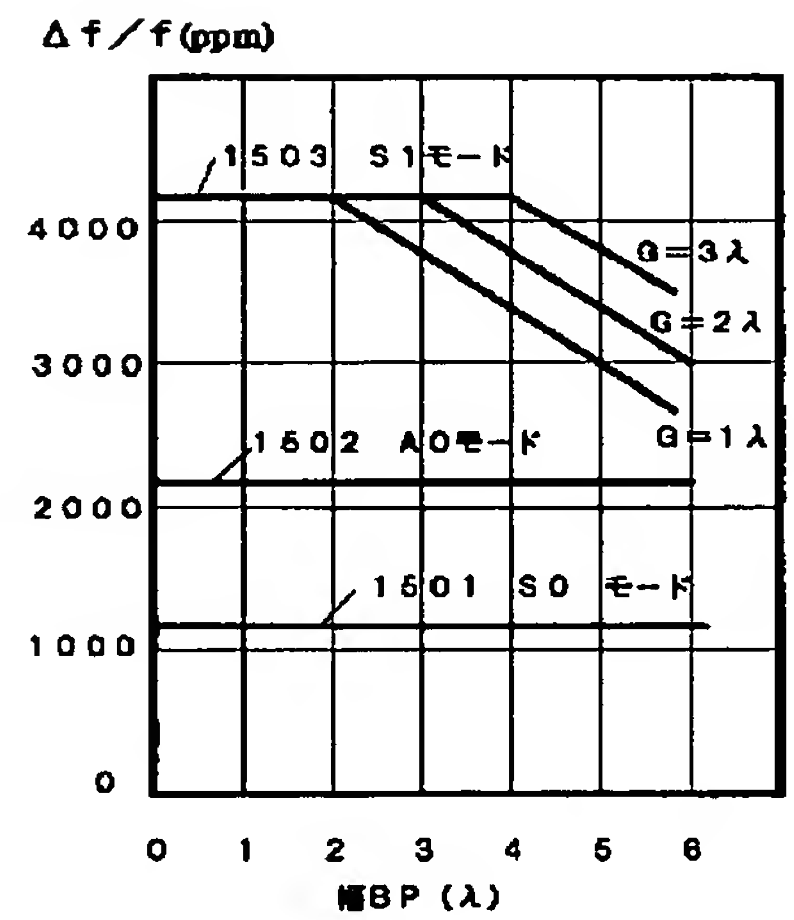
【図６】



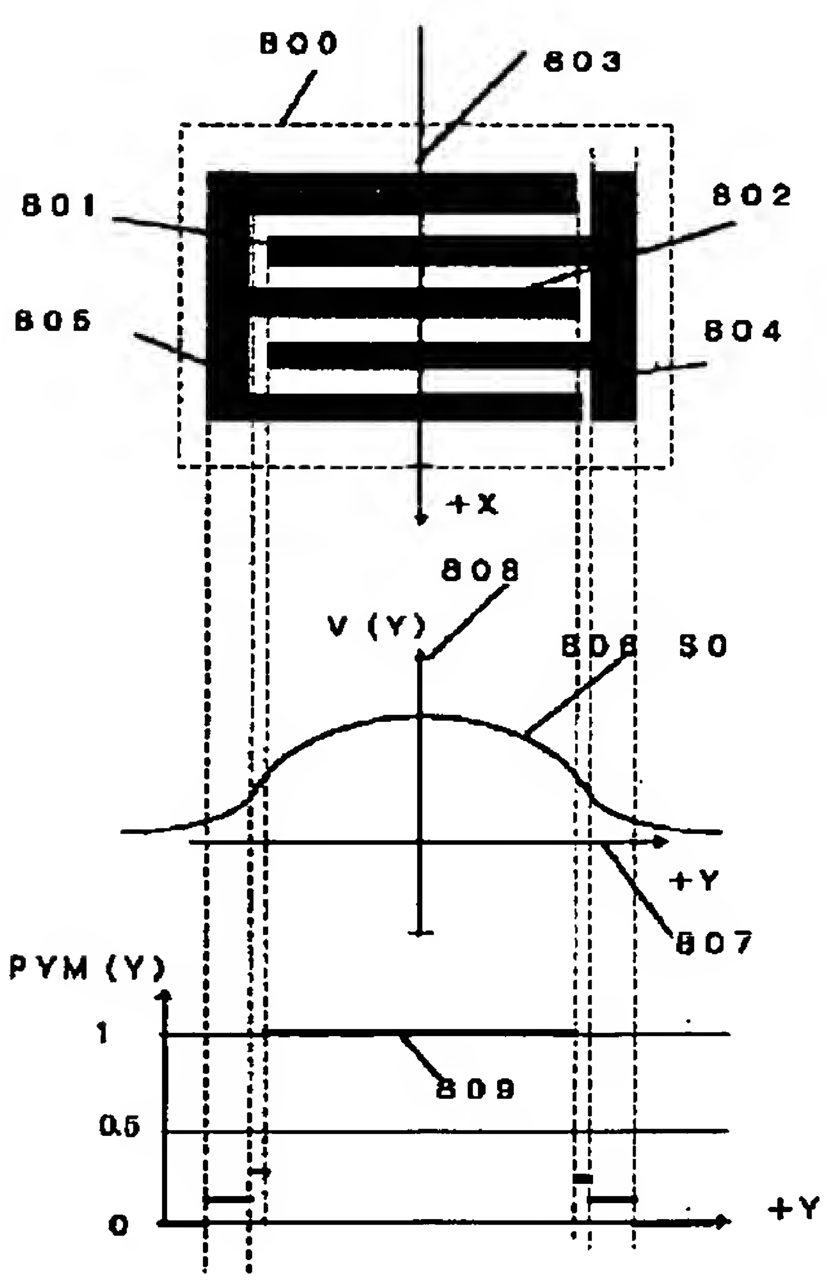
【図７】



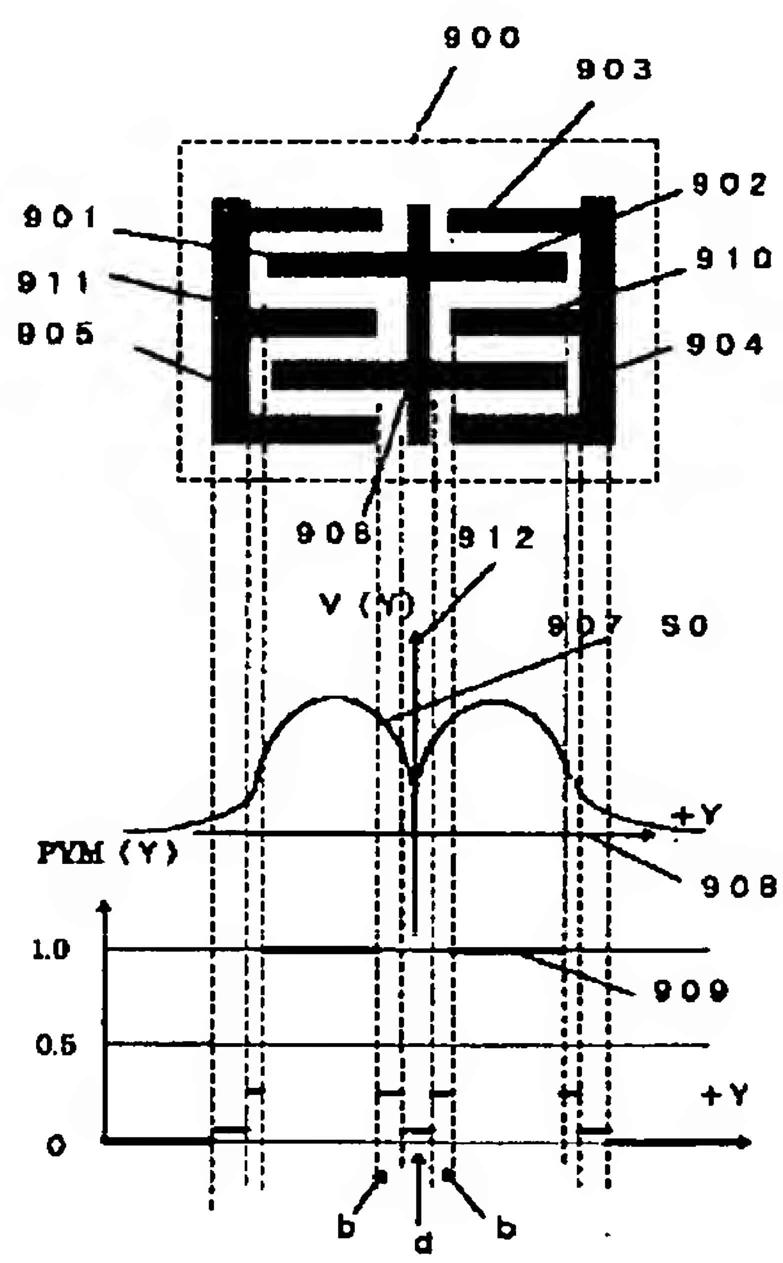
【図１５】



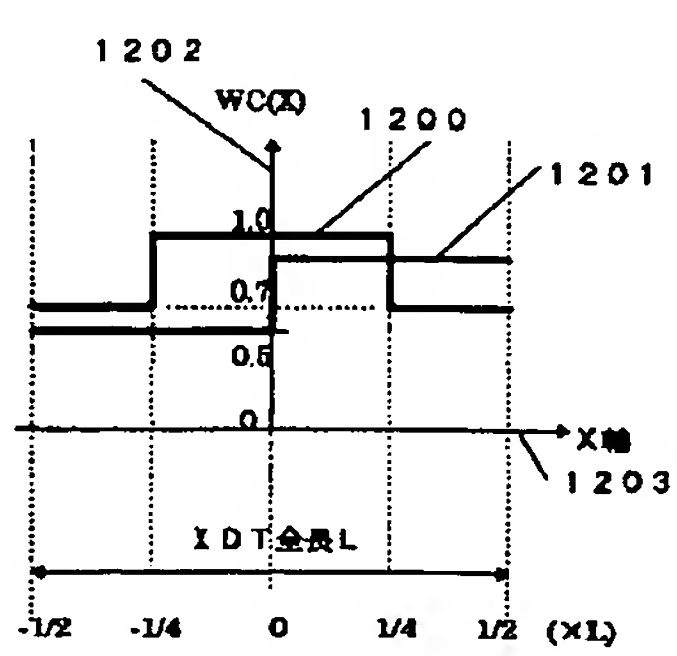
【図８】



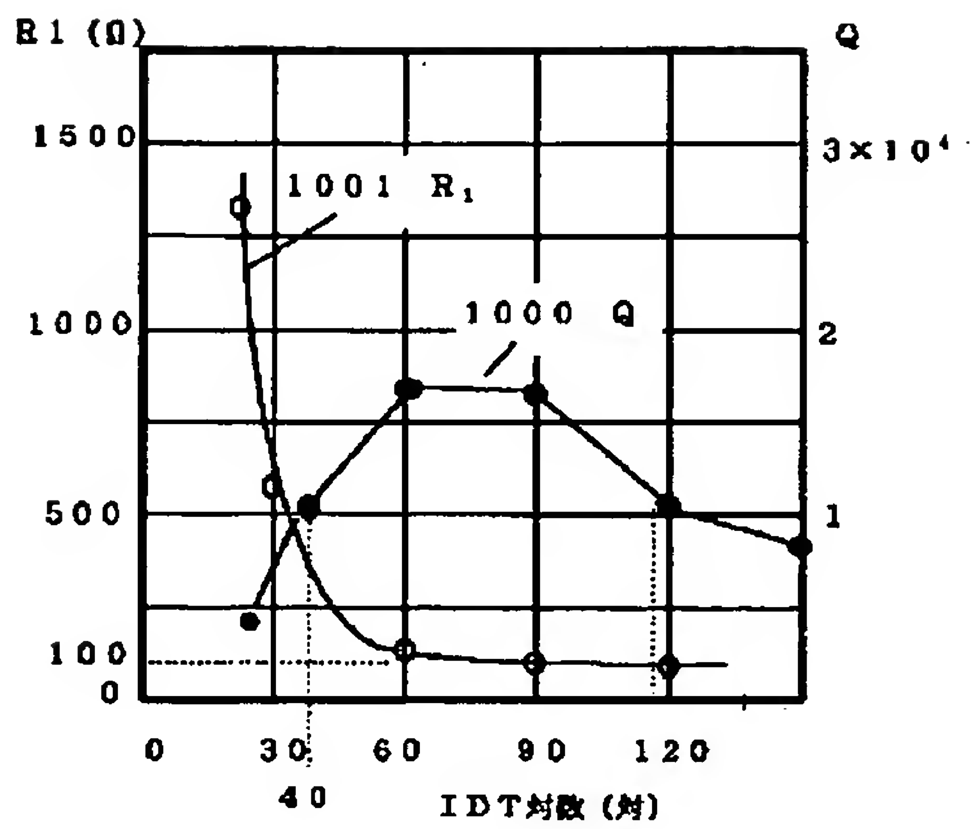
【図９】



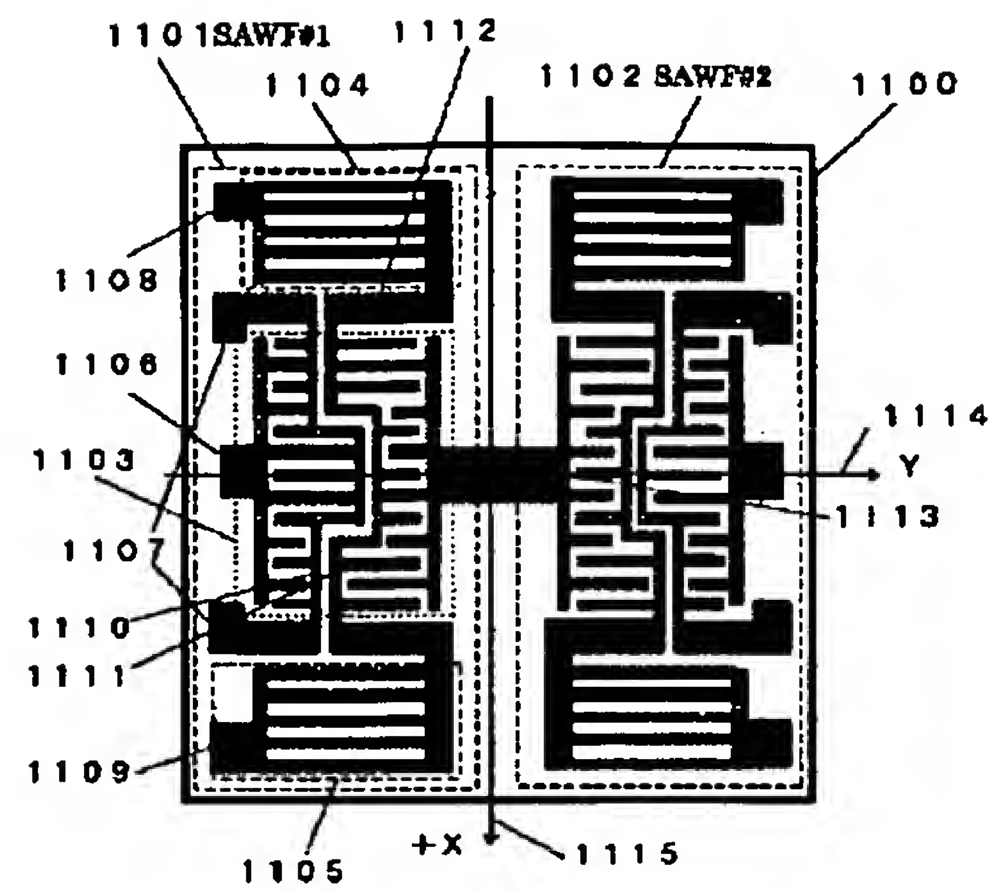
【図１２】



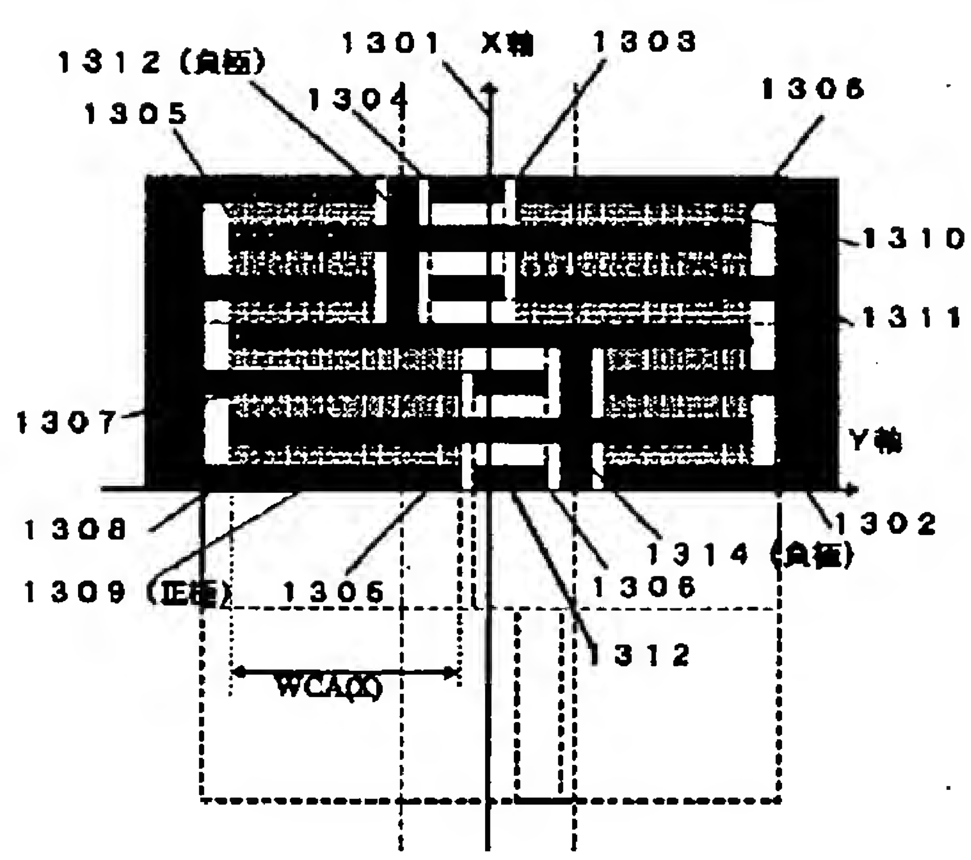
【図10】



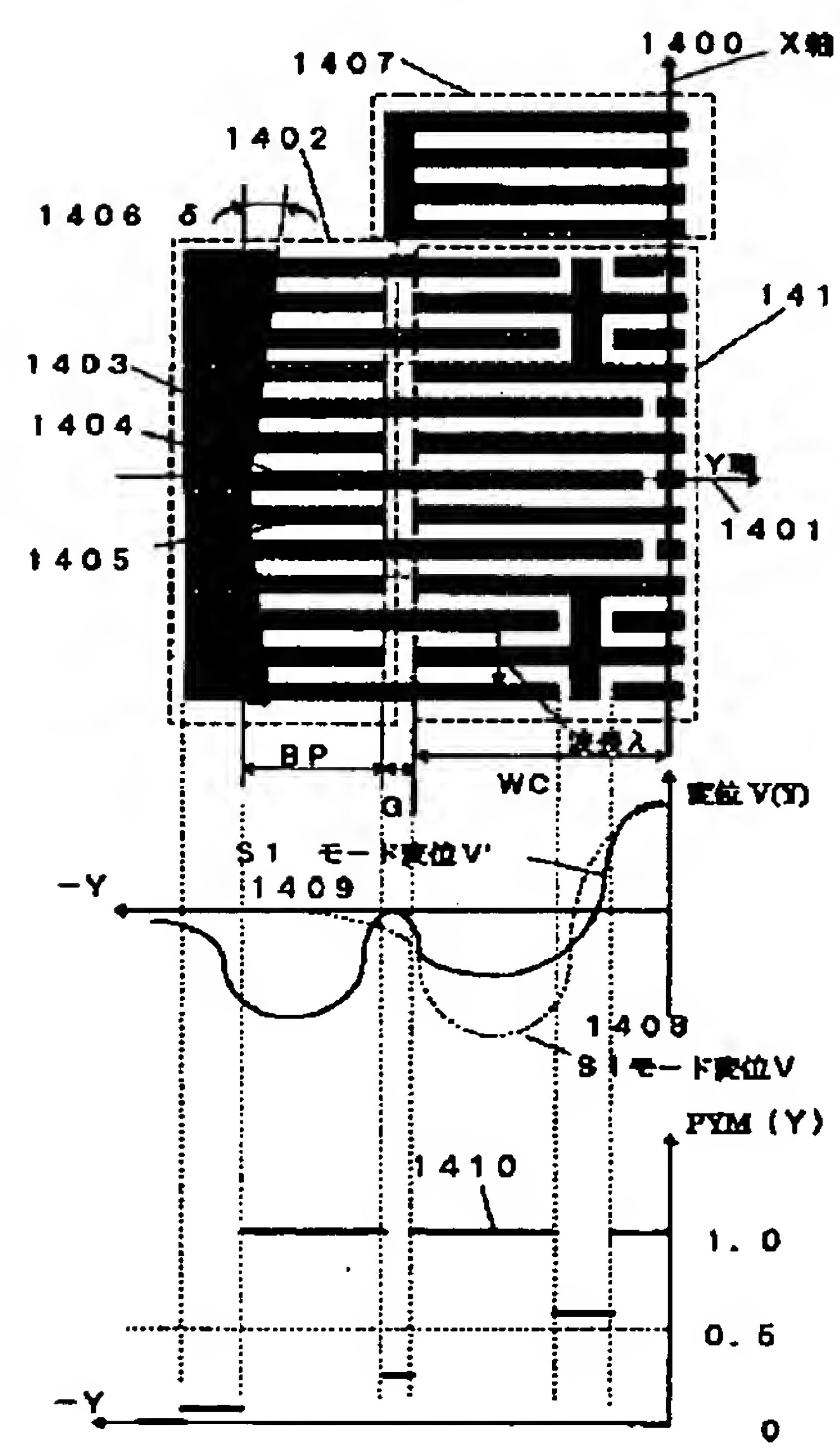
【図11】



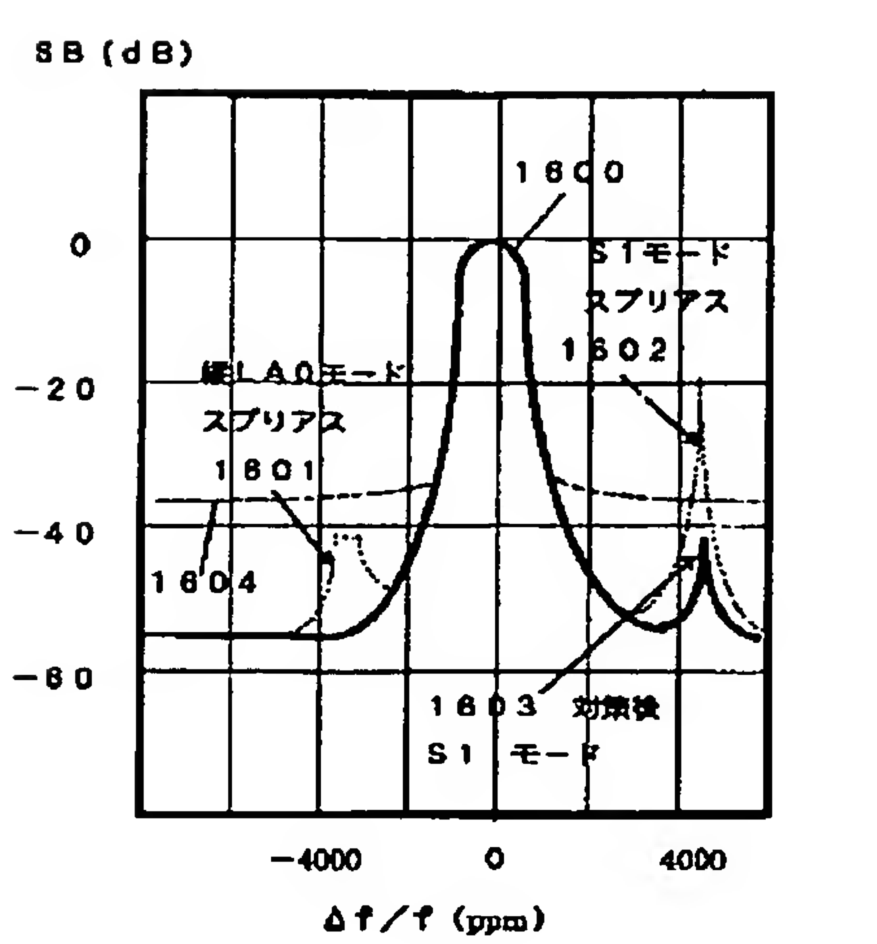
【図13】



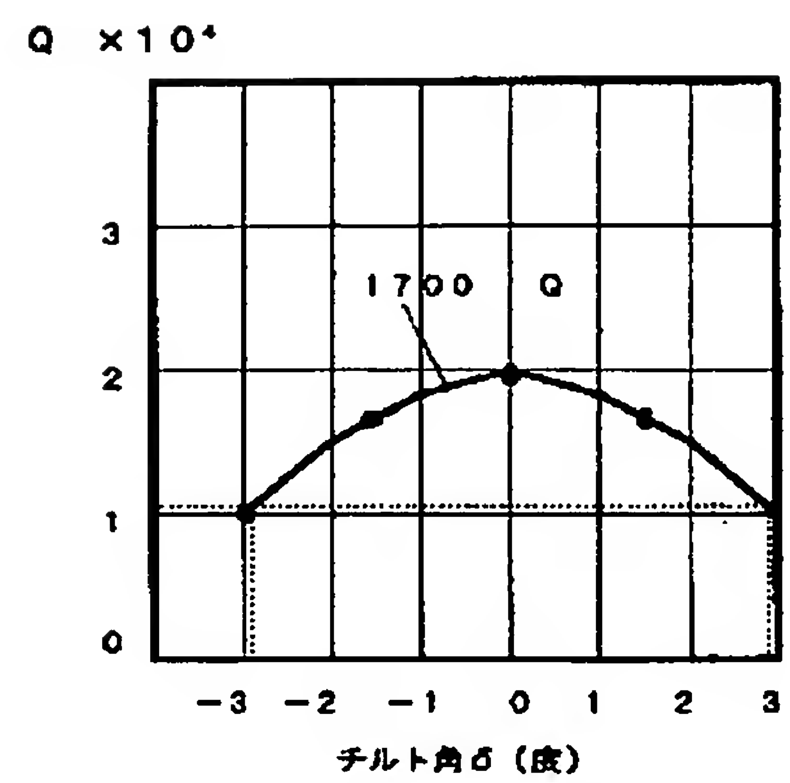
【図14】



【図16】



【図１７】



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HAYASHI SATOSHI

YAMAZAKI TAKASHI

(30)Priority

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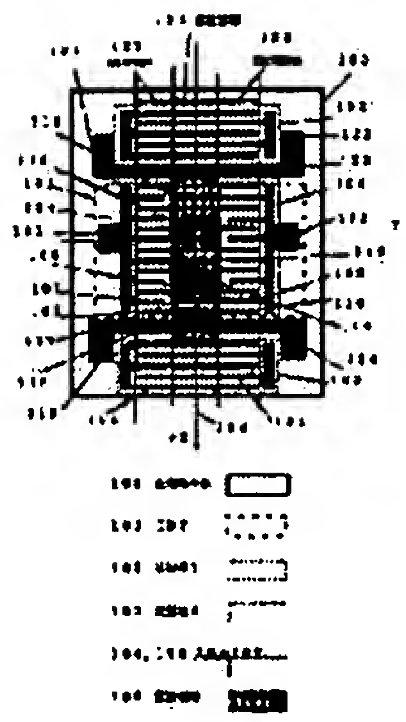
(54) LATERAL DUAL MODE SAW FILTER



(57)Abstract:

PROBLEM TO BE SOLVED: To provide an excellent intermediate frequency filter applicable to a portable telephone set such as a PHS and a GSM by attaining a broad frequency band and miniaturization of the lateral dual mode SAW filter (high frequency narrow band multiplex mode filter) employing, e.g. a crystal substrate.

SOLUTION: In th case of integrating IDTs 101 of two SAW resonators 127, 129, a frequency of a basic wave symmetrical mode SO of two specific vibration modes in use is decreased by arranging a shared feed-conductor pattern (bus bar) on the negative polarity side in such a way that a plurality (two or over) of positions are taken in the width direction and this arrangement is repeated periodically in a propagation direction X of a surface acoustic wave, thereby extending the pass band width of the filter.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

CLAIMS

[Claim(s)]

[Claim 1] Since the surface acoustic wave which at least one blind-like electrode and said blind-like electrode generate is reflected in the both sides on piezo electric crystal monotonous, In the horizontal duplex mode SAW filter which adjoined each other to the propagation direction X of said surface acoustic wave, and has arranged two SAW resonators with one pair of reflectors almost in parallel the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have -- a conductor Make the shape of a square wave as plurality, and the coordinate location which breaks crosswise which makes it one, and uses in common, and intersects perpendicularly in the

aforementioned propagation direction X is formed. The horizontal duplex mode SAW filter characterized by for the crossover electrode digit WC of said blind-like electrode taking two or more dimensions, meeting in the direction of X, and changing with these by turns.

[Claim 2] the electric supply by the side of the negative electrode which said blind-like electrode has -- the horizontal duplex mode SAW filter according to claim 1 to which the coordinate location of the direction of Y of a conductor is characterized by taking two Y coordinate (Y1, Y2) by turns.

[Claim 3] the electric supply by the side of the negative electrode of said blind-like electrode to share -- the horizontal duplex mode SAW filter according to claim 1 to which the direction electrode width of face of X of the part (113,114) crossed crosswise sets wavelength of a surface acoustic wave to lambda, and is characterized by being lambda/4 of odd times about a conductor.

[Claim 4] The horizontal duplex mode SAW filter according to claim 1 to which the dimension WC12 of the field which overlaps crosswise [of said blind-like electrode] sets wavelength of a surface acoustic wave to lambda, and is characterized by being the range below 5lambda more than from 2lambda.

[Claim 5] The horizontal duplex mode SAW filter according to claim 1 characterized by compounding the transmission characteristic of said horizontal duplex mode SAW filter from the fundamental-wave symmetric mode S0 belonging to the transverse mode, and the fundamental-wave oblique symmetry mode A0.

[Claim 6] The horizontal multiplex-mode SAW filter according to claim 1 characterized by for said piezo electric crystal plate being Xtal, and being ST cut X propagation bearing of a 30 - 45-degree rotation Y cut.

[Claim 7] The horizontal duplex mode SAW filter according to claim 1 to which said piezo electric crystal plate is Xtal, and it is ST cut of a 30 - 45-degree rotation Y cut, and the sum total (WCT=WC1+WC2+WC12+G1+G2) of the width of face of said blind-like electrode is characterized by 12lambda to 20lambda carrying out the range, having used wavelength of a surface acoustic wave as

lambda.

[Claim 8] the logarithm of the blind-like electrode which said one SAW resonator has -- the conductor of 120 to 60 pairs of range, and a single-sided reflector -- the horizontal duplex mode SAW filter according to claim 1 characterized by a number being within the limits of 80 to 140.

[Claim 9] the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have -- the horizontal duplex mode SAW filter according to claim 1 characterized by having divided the conductor into two in the center of the cross direction, and insulating between I/O side terminal pairs electrically by this.

[Claim 10] the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have -- the horizontal duplex mode SAW filter according to claim 1 to which the coordinate location where a conductor breaks crosswise which intersects perpendicularly in the aforementioned propagation direction X is taken even times, the shape of a square wave is made and formed, and change of the crossover electrode digit WC of said blind-like electrode is characterized by to be axial symmetry to Chuo Line of said X shaft orientations by this.

[Claim 11] The horizontal duplex mode SAW filter according to claim 1 characterized by having prepared the part without a thin conductor and the width of face WCA which the electrode finger of the forward negative polarity of said blind-like electrode intersects carrying out division separation of one of the polar electrode finger patterns so that crosswise Chuo Line of said two SAW resonators may not be crossed.

[Claim 12] The horizontal duplex mode SAW filter given in claim 1 written to which the electrode gross area which the width of face WCA which the electrode finger of the forward negative polarity of the blind-like electrode which said two SAW resonators have intersects forms is characterized by the mutual electrode gross area about said fundamental-wave symmetric mode S0 and the fundamental-wave oblique symmetry mode A0 being almost equal equally [to

mutual].

[Claim 13] the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have -- a conductor Take the coordinate location which breaks crosswise which intersects perpendicularly in the aforementioned propagation direction X even times, and the shape of a square wave is made and formed. Change of the crossover electrode digit WCA of said blind-like electrode receives Chuo Line of said X shaft orientations by this. Axial symmetry and nothing, The width of face WCA which the electrode finger of the forward negative polarity of said blind-like electrode intersects so that crosswise Chuo Line of said two SAW resonators may not be crossed the electrode gross area which the width of face WCA which the electrode finger of the forward negative polarity of the blind-like electrode with which a part without a thin conductor is prepared, division separation is carried out, and said two SAW resonators have an electrode finger pattern intersects forms equally to mutual The horizontal duplex mode SAW filter according to claim 1 characterized by doubling and having having also **(ed) mostly the mutual electrode gross area about said fundamental-wave symmetric mode S0 and the fundamental-wave oblique symmetry mode A0.

[Claim 14] A horizontal duplex mode SAW filter given in either of claims 1-13 characterized by cascading two steps of said horizontal duplex mode SAW filter.

[Claim 15] Since the surface acoustic wave which at least one blind-like electrode and said blind-like electrode generate is reflected in the both sides on piezo electric crystal monotonous, In the horizontal duplex mode SAW filter which adjoined each other to the propagation direction X of said surface acoustic wave, and has arranged two SAW resonators with one pair of reflectors almost in parallel On the outside of the cross direction of the blind-like electrode formed as it is also at the crossover electrode digit WC which said two SAW resonators have, and a reflector field the space length G -- separating -- vibration of the primary horizontal symmetric mode S1 -- the horizontal duplex mode SAW filter characterized by preparing the electrode field of the shape of a grating of the

width of face BP formed with the electrode fingers which consist only of the same polarity which was made to reveal that it is only strange, and was constituted so that it might be made to decrease.

[Claim 16] The horizontal duplex mode SAW filter according to claim 15 to which the number of said space length G is three from two waves of a surface acoustic wave, and width of face BP of the electrode field of the shape of said grating is characterized by being four waves from three waves.

[Claim 17] the electric supply which short-circuits the edge of the electrode fingers which form the electrode field of the shape of said grating, and supplies a current -- the horizontal duplex mode SAW filter according to claim 15 characterized by for the inside of a conductor having met the propagation direction X shaft orientations of said surface acoustic wave, and making a taper-like configuration.

[Claim 18] the electric supply which short-circuits the edge of the electrode fingers which form the electrode field of the shape of said grating, and supplies a current -- the horizontal duplex mode SAW filter according to claim 17 characterized by for the inside of a conductor having met the propagation direction X shaft orientations of said surface acoustic wave, and making the configuration of the shape of a taper of 2 to 3 times.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the horizontal duplex mode SAW filter which realized broadband-ization of a filter in the resonator mold SAW filter constituted using a surface acoustic wave using the two independent transverse modes obtained by carrying out parallel arrangement of the SAW resonator beside two.

[0002]

[Description of the Prior Art] As a horizontal duplex mode SAW filter of the conventional resonator mold, the so-called horizontal duplex mode SAW filter (an alias name RF narrow-band multiplex-mode filter) which carried out parallel arrangement of the two SAW resonators is famous by its side (JP,2-16613,B). If a filter is constituted from a Xtal ST cut X propagation substrate which is a rotation Y cut of about 30 to 45 degrees in which the frequency temperature characteristic was excellent using this method, the flat-surface size of a component expresses by 2mmx6.5mm, 3dB bandwidth of a two-step subordination connection filter expresses with fractional band width, and about 700 ppm and the outstanding property of 5dB of insertion losses are acquired.

[0003]

[Problem(s) to be Solved by the Invention] However, if the conventional technique of the above-mentioned horizontal duplex mode SAW filter was used, it had the fractional band width of 1 900 to 1000 ppm demanded in the intermediate frequency filter (IF filter) used for the cellular phone of the GSM method which shows development remarkable in recent years, or a PHS method, and a thing with a 2 and a flat-surface size [of a container] of less than 3.8x3.8mm was not able to be realized by the engine performance can be satisfied with said Xtal ST cut of the engine performance.

[0004] It is not rich and about the fractional band width which analyzes an unrealizable cause and which is the technical problem of 1 In nine waves from the width method 7 of one SAW resonator the appropriate filter impedance Z0 is obtained in the above-mentioned conventional technique The delta frequency of the two independent native modes S0 (fundamental-wave symmetric mode) and A0 (fundamental-wave oblique symmetry mode) which has determined the aforementioned fractional band width is because it does not become larger than this by about 700 ppm. About the size which is next the technical problem of 2, in containing a component in the aforementioned container flat-surface size The blind-like electrode which constitutes one SAW resonator by setting component size to about 2x3mm (henceforth) the electrode finger which made one pair the forward negative electrode which is omitted and is written as IDT (Interdigital Transducer) -- the reflector of M pairs of logarithms, and one side -- a conductor -- the sum of Number N It is necessary to make M+N or less into about 200. For this reason, the excitation reinforcement and the displacement transfer factor of resonance amplitude of a SAW resonator which constitute a horizontal duplex mode SAW filter will decrease, and the transmission characteristic of said SAW filter will deteriorate [free].

[0005] in order [furthermore,] to improve the insertion loss which is the one property of the aforementioned transmission characteristics as the 3rd technical problem -- a reflector -- a conductor -- although it is possible to thicken electrode layer thickness in order to compensate the insufficiency of a number, length and horizontal higher-mode spurious level will increase by this.

[0006] Then, it is in there being nothing to the former, and excelling broadband-izing and a miniaturization of pass band width in a scale and frequency stability, and S/N providing a commercial scene with a good IF filter using the substrate in which this invention solves such a trouble, and the purpose was excellent in the frequency temperature characteristic like the Xtal ST cut, and the Q value of an ingredient was excellent.

[0007]

[Means for Solving the Problem] (1) The horizontal duplex mode SAW filter of this invention Since the surface acoustic wave which at least one blind-like electrode and said blind-like electrode generate is reflected in the both sides on piezo electric crystal monotonous, In the horizontal duplex mode SAW filter which adjoined each other to the propagation direction X of said surface acoustic wave, and has arranged two SAW resonators with one pair of reflectors almost in parallel the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have -- a conductor It is characterized by making the shape of a square wave as plurality, forming the coordinate location which breaks crosswise which makes it one, and uses in common, and intersects perpendicularly in the aforementioned propagation direction X, for the crossover electrode digit WC of said blind-like electrode taking two or more dimensions, meeting in the direction of X by this, and changing by turns.

[0008] (2) the electric supply by the side of the negative electrode which said blind-like electrode has in the above (1) -- the direction coordinate location of X of a conductor is characterized by taking two Y coordinate (Y1, Y2) by turns.

[0009] (3) the above (1) -- setting -- the electric supply by the side of the negative electrode of said who-like electrode to share -- about a conductor, the direction electrode width of face of X of the part (113 114) crossed crosswise sets wavelength of a surface acoustic wave to lambda, and is characterized by being lambda/4 of odd times.

[0010] (4) In the above (1), the dimension WC12 of the field where the electrode finger crossover width of face which said two SAW resonators have overlaps about the cross direction sets wavelength of a surface acoustic wave to lambda, and is characterized by being the range below 5lambda more than from 2lambda.

[0011] (5) In the above (1), the transmission characteristic of said horizontal duplex mode SAW filter is characterized by being compounded from the fundamental-wave symmetric mode S0 belonging to the transverse mode, and the fundamental-wave oblique symmetry mode A0.

[0012] (6) In the above (1), said piezo electric crystal plate is Xtal, and it is

characterized by being ST cut X propagation bearing of a 30 - 45-degree rotation Y cut.

[0013] (7) In the above (1), said piezo electric crystal plate is Xtal, and it is ST cut of a 30 - 45-degree rotation Y cut, and the sum total (WCT=WC1+WC2+WC12+G1+G2) of the width of face of said blind-like electrode is characterized by 12lambda to 20lambda carrying out the range, having used wavelength of a surface acoustic wave as lambda.

[0014] (8) the logarithm of the blind-like electrode which said one SAW resonator has in the above (1) -- the conductor of 120 to 60 pairs of range, and a single-sided reflector -- it is characterized by a number being within the limits of 80 to 140.

[0015] (9) the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have in the above (1) -- it is characterized by having divided the conductor into two in the center of the cross direction, and insulating between I/O side terminal pairs electrically by this.

[0016] (10) the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have in the above (1) -- the coordinate location where a conductor breaks crosswise which intersects perpendicularly in the aforementioned propagation direction X is taken even times, the shape of a square wave is made and formed, and change of the crossover electrode digit WCA of said blind-like electrode is characterized by to be axial symmetry to Chuo Line of said X shaft orientations by this.

[0017] (11) In the above (1), width of face WCA which the electrode finger of the forward negative polarity of said blind-like electrode intersects is characterized by having prepared the part without a thin conductor and carrying out division separation of one of the polar electrode finger patterns so that crosswise Chuo Line of said two SAW resonators may not be crossed.

[0018] (12) In the above (1), the electrode gross area which the width of face WCA which the electrode finger of the forward negative polarity of the blind-like electrode which said two SAW resonators have intersects forms is characterized

by the mutual electrode gross area about said symmetric mode S0 and oblique symmetry mode A0 being almost equal equally [to mutual].

[0019] (13) the electric supply by the side of the negative electrode of the blind-like electrode which said two SAW resonators have in the above (1) -- a conductor Take the coordinate location which breaks crosswise which intersects perpendicularly in the aforementioned propagation direction X even times, and the shape of a square wave is made and formed. Change of the crossover electrode digit WCA of said blind-like electrode receives Chuo Line of said X shaft orientations by this. Axial symmetry and nothing, The width of face WCA which the electrode finger of the forward negative polarity of said blind-like electrode intersects so that crosswise Chuo Line of said two SAW resonators may not be crossed the electrode gross area which the width of face WCA which the electrode finger of the forward negative polarity of the blind-like electrode with which a part without a thin conductor is prepared, division separation is carried out, and said two SAW resonators have an electrode finger pattern intersects forms equally to mutual The mutual electrode gross area about said symmetric mode S0 and oblique symmetry mode A0 is also characterized by doubling and having having made it almost equal.

[0020] (14) It is characterized by cascading two steps of said horizontal multiplex-mode SAW filter in either of (13) from the above (1).

[0021] (15) The horizontal duplex mode SAW filter of this invention Since the surface acoustic wave which at least one blind-like electrode and said blind-like electrode generate is reflected in the both sides on piezo electric crystal monotonous, In the horizontal duplex mode SAW filter which adjoined each other to the propagation direction X of said surface acoustic wave, and has arranged two SAW resonators with one pair of reflectors almost in parallel On the outside of the cross direction of the blind-like electrode formed as it is also at the crossover electrode digit WC which said two SAW resonators have, and a reflector field It is characterized by preparing the electrode field of the shape of a grating of the width of face BP formed with the electrode fingers which consist

only of the same polarity constituted so that the space length G might be separated, the vibration displacement of the primary horizontal symmetric mode S1 might be made to reveal and it might be made to decrease.

[0022] (16) In the above (1) and (10), the number of said space length G is three from two waves of a surface acoustic wave, and width of face BP of the electrode field of the shape of said grating is characterized by being four waves from three waves.

[0023] (17) the electric supply which short-circuits the edge of the electrode fingers which form the electrode field of the shape of said grating in the above (15), and supplies a current -- it is characterized by for the inside of a conductor having met the propagation direction X shaft orientations of said surface acoustic wave, and making a taper-like configuration.

[0024] (18) the electric supply which short-circuits the edge of the electrode fingers which form the electrode field of the shape of said grating in the above (17), and supplies a current -- it is characterized by for the inside of a conductor having met the propagation direction X shaft orientations of said surface acoustic wave, and making the configuration of the shape of a taper of 2 to 3 times.

[0025]

[Embodiment of the Invention] About this invention, before explaining a concrete example, theoretical description is performed, and an understanding of this invention will be helped.

[0026] A plate is cut down from piezo electric crystal ingredients, such as Xtal, lithium tantalate, PZT, and a tetraboric acid lithium. After carrying out mirror polishing of the front face, it intersects perpendicularly to the phase propagation direction of surface acoustic waves, such as the Rayleigh mold, a ram mold, the Leakey mold, and a BGS wave. for example, a large number which consist of metal aluminum are parallel -- IDT which has arranged the electrode finger of a conductor periodically is formed, further, many strip conductors are arranged in parallel and periodically on the both sides, the reflector of a pair is constituted on them, and the SAW resonator of 1 port mold is formed.

[0027] In the aforementioned SAW resonator, as the main point at the time of constituting said IDT, when it considers as M pairs, having used a positive electrode and the negative electrode as one pair, after defining total reflection coefficient ** in the whole electrode finger of IDT as a degree type (1) 10>**> It is known that the so-called energy confinement mold SAW resonator (bibliography: an energy ****** surface acoustic wave resonator, the **** technique US 87-36, pp 9-16 (1987. 9.)) which 0.8, then vibrational energy concentrated in the center of a resonator will be realizable.

[0028]

[Equation 1]

** -- = 4 MbH/lambda (1)

However, for M, said logarithm of IDT and b are [the thickness of said conductor and lambda of the reflection coefficient of the surface acoustic wave per electrode and H] the wavelength of a surface acoustic wave here.

[0029] For example, if it is IDT formed with said aluminum conductor steel reinforced with ST cut quartz plate, M= 80 pairs, then the 1 port SAW resonator of drawing 1 can be constituted as b= 0.255 and H/lambda =0.03. At this time, it becomes about gamma= 2.448. Therefore, about M= 80 to 1 port mold SAW resonator is used for the horizontal duplex mode SAW filter of this invention, and it is thought possible to achieve the miniaturization of component size (technical problem 2 which invention tends to solve).

[0030] Furthermore, since in solving the technical problem 1 which invention in the horizontal duplex mode SAW filter of this invention tends to solve the vibration displacement and resonance frequency in the mode called the so-called transverse mode were computed using the theory expressed below and the filter was designed, these contents are explained in order. Said transverse mode is the normal mode of vibration which exists depending on the die length of the cross direction (Y shaft orientations which intersect perpendicularly to the propagation direction X of a surface acoustic wave) of a SAW resonator, and it is common that the die length of said cross direction points out the electrode finger

crossover width of face WC which IDT has. In this electrode finger crossover width of face WC, it is the dimension of the cross direction where the electrode finger of straight polarity and negative polarity serves as arrangement which laps mutually.

[0031] Next, the writer etc. draws and exhibits the differential equation which already governs these transverse modes as an approach for calculating the vibration displacement of a SAW resonator simple about the cross direction (it considers as a Y-axis) of the aforementioned SAW resonator (a tree, Momozaki, others: "dynamic in ordinary temperature and a K cut Xtal SAW resonator with a static zero temperature coefficient", Institute of Electrical Engineers of Japan electronic-circuitry technical-committee 25thEM symposium and pp 79-80, (1996)). Anew, it will become an equation (2) if this equation is described.

[0032]

[Equation 2]

aomega02(Y) V(Y) YY+{omega2-omega02 (Y)} V(Y) =0 (2)

the component angular frequency of the field where angular frequency and omega 0 (Y) correspond here in omega, and a -- a crosswise effectual shear stiffness constant and V (Y) -- a crosswise surface acoustic wave -- the amplitude of a variation rate and Y are the Y coordinate standardized on the wavelength of a surface acoustic wave. Moreover, omega 0 (Y) is the amount which converted the rate of the surface acoustic wave in Coordinate Y into angular frequency, and it will be called a frequency potential function. This frequency potential function changes with the functions of thickness [of the aluminum metallic conductor film which exists in the propagation path of a surface acoustic wave] H (Y) [near the operating point of a SAW resonator]. More generally changing with the function of mass [of an aluminum metal] m (Y) is checked. Therefore, in the blind-like polar zone which constitutes the principal part of a SAW resonator, omega 0 (Y) is mostly determined by mass m (Y) which a blind-like electrode has. That is, it is omega 0 (m (Y)). In the aforementioned Xtal ST-cut, since film thickness is thin, above omega 0 (Y) descends linearly

proportionally mostly to m.

[0033] It is [0034] when it divides by the frequency omega 002 used as criteria in a formula (2), in order to simplify count here.

[Equation 3]

aQ2(Y) V(Y) YY+{omega2-Q2(Y)} V(Y) =0 (3)

Here, omega=omega/omega 00 serves as normalized radiam frequency, and Q (m (Y)) serves as a potential function.

[0035] Displacement amplitude V (Y) The approach of searching for is calculable by the integral serially as follows, for example.

[0036]

[Equation 4]

$$V(Y,\Omega)=\int_0^Y V(Y)_{,Y}\,dY+c\ (定数)\qquad(4)$$

ただし、 $$V(Y,\Omega)_{,Y}=-\int_0^Y \{\Omega^2-Q^2(Y)\}\,V(Y)/aQ^2(Y)\,dY$$

Although V (Y, omega) of a formula (4) is the function of normalized radiam frequency, the displacement amplitude which occurs actually is obtained in omega given by the degree type which is the minimum principle of energy.

[0037]

[Equation 5]

$$\partial(2E(\Omega))/\partial\Omega=\int_0^\infty V^2(Y,\Omega)\,dY=0\qquad(5)$$

It is the basic type of count which (5) used for this invention from the above formula (1), and the horizontal duplex mode SAW filter which becomes the below-mentioned concrete example using these is designed, and since the prototype was manufactured and measured, these are explained in order.

[0038] (Example 1) Order is hereafter explained for the gestalt of operation of this invention later on from drawing 1 . Drawing 1 is the example 1 which expressed

the electrode pattern used for the horizontal duplex mode SAW filter which is a kind of the horizontal multiplex-mode SAW filter of this invention with the top view. In addition, the shaft with which +X shaft orientations, the aforementioned +X, and 126 cross at right angles shows the direction of +Y.

[0039] For the name like each part in drawing 1 , as for a piezo electric crystal plate and 101, the whole blind-like electrode of a horizontal duplex mode SAW filter, i.e., all IDT(s), and 102 and 103 is [100] the reflectors 1 and reflectors 2 of a horizontal duplex mode SAW filter respectively. said total -- the field which is the part of IDT (101) and where 104 surrounded with the broken line consists only of an input IDT of the SAW resonator 1 (SAWR#1) -- it is -- 106 -- again -- It is the field which consists only of an output IDT of the SAW resonator 2 (SAWR#2). Furthermore, the field of 105 surrounded with the broken line is a duplication field where IDT of said SAW resonator 1 of 104 and 106 and SAW resonator 2 crosses and exists. 107 is one of the electrode fingers by the side of the positive electrode of said input IDT, and 108 is one of the electrode fingers by the side of a negative electrode (naturally, although an I/O signal is a RF AC signal, for convenience, one side is called a positive electrode and it is calling another side the negative electrode here.). Moreover, 109 is one of the electrode fingers by the side of the positive electrode of said output IDT, and 110 is one of the electrode fingers by the side of a negative electrode. 111 and 112 are the positive-electrode terminals (pad) of an input or an output. The pattern of 113 and 114 grades is for connecting between the patterns of 117 grades with 115 and 116,116 crosswise (Y). the electric supply to which said 115 and 116,117 connect the edge of the electrode fingers by the side of said two negative polarity, the input IDT of the SAW resonator 1, and the output IDT of the SAW resonator 2, -- a conductor is shared and pattern formation is carried out to one. thus, the thing to constitute -- electric supply -- the coordinate location where a conductor breaks crosswise which intersects perpendicularly in the propagation direction X of a surface acoustic wave -- plurality -- **** -- the shape of a square wave is made and it will be formed. The crossover electrode digit of IDT will take two or

more dimensions, will meet in the direction of X, and it will change with these by turns. And a pattern 115,117 will take 1st Y coordinate Y1, and a pattern 116 will take 2nd Y coordinate Y2.

[0040] 118 is a conductor pattern for the conductor pattern for connecting between the pads of 119 and 120 with 117 and 123 to connect between 122 with a pad 121. 119, and 120, 121 and 122 are pads which give the potential by the side of the negative electrode of said I/O IDT. 124 and 125 grades -- the conductor of a reflector 2 -- it is a strip and the duty which reflects a surface acoustic wave is achieved. In this case, although it does not connect mutually, said 124 and 125 may be the case where it connects. The field of the arrow head of 127 consists of some of two reflectors 1, reflectors 2, and the part of all IDT(s)101, and constitutes the SAW resonator 1 on the whole. Moreover, the field of the arrow head of 129 consists of some of two reflectors 1, reflectors 2, and the part of all IDT(s)101, and constitutes the SAW resonator 2 on the whole. The field of the arrow head of further 128 shows the duplication field where IDT of said SAW resonator 1 and SAW resonator 2 crosses.

[0041] The piezo electric crystal plate of 100 consists of a substrate in which piezoelectric thin films which have piezoelectric [of Xtal, lithium tantalate, a tetraboric acid lithium, etc.], such as a single crystal and ZnO, were formed etc. After carrying out thin film formation of the metal membrane which has the conductivity of aluminum, gold, etc. with means, such as vacuum evaporationo and a spatter, pattern formation of IDT, a reflector, etc. which constitute the two aforementioned SAW resonators 127, 128, and 129 formed on above 100 is carried out with a photolithography technique, and they are made. The electrode fingers of said IDT and reflector intersect perpendicularly to the phase travelling direction (longitudinal direction +X) of the surface acoustic waves (the Rayleigh wave, Leakey wave, etc.) to be used, and are arranged in parallel and periodically. [much] The reflector of 102 and 103 illustrated as one example forms the electrode pattern for exciting the oscillation mode alternatively, and is an object for the fundamental-wave symmetric modes S0 as an example.

[0042] (Example 2) Next, drawing 2 is one example which cascaded two steps of horizontal duplex mode SAW filters of above-mentioned drawing 1 . 201 by which, as for the name like each part in drawing, 200 was surrounded with the piezo electric crystal plate and the fine broken line is the 1st horizontal duplex mode SAW filter (SAWF#1), and 202 is the 2nd horizontal duplex mode SAW filter (SAWF#2). The pad with which 205, and 206, 207 and 208 give the negative-electrode potential by the side of an input or an outgoing end, and 203 and 204 are pads which give the positive-electrode potential by the side of an input or an output terminal. Moreover, 210 and 211 are conductor patterns which connect between the negative electrodes between 2nd horizontal duplex mode SAW filter 201 and 202 with the 1st. Furthermore, 209 is a conductor pattern which connects between the positive electrodes between 2nd horizontal duplex mode SAW filter 201 and 202 with the 1st.

[0043] Next, detailed explanation is given using drawing 3 per configuration of all IDT(s) (101 of drawing 1) used for drawing 1 and drawing 2 of this invention. 300 surrounded with the broken line in drawing supports a part of 101 of said drawing 1 . Said 300 of the whole consists of composition of five fields surrounded with the fine broken line, and they consist of joint fields 302 and 303 of 12 or 2 IDT(s) of IDT2,315 of IDT1,304 of 301. the cross bus bar which connects to the 1st electric supply conductor pattern 308 310 which is one of the electrode fingers of the negative electrode of IDT1, and is crossed crosswise [of further 309] (Y shaft orientations) -- minding -- the 2nd negative polarity side electric supply -- it has connected with a conductor 307. The dimension of the direction of X of the cross bus bar part (equivalent to 113,114 of drawing 1) crossed crosswise [said / of 309] (Y shaft orientations) takes one odd times the value of 1/4lambda (lambda is the wavelength of a surface acoustic wave) which is the dimension which does not generate spurious resonance. Since the same is said also of 210 and 211 of 123, 118, and drawing 2 of drawing 1 </A> with the occasion, one odd times the value of 1/4lambda (lambda is the wavelength of a surface acoustic wave) is taken. By fields 302 and 315 and the 303 whole, the duplication field of

128 of drawing 1 is covered. 305 -- the electric supply by the side of the straight polarity of Input IDT (IDT1) -- a conductor and 306 -- straight polarity side electric supply of an output IDT (IDT2) -- it is a conductor. For 301, WC 1,302G1,315 is [WC 12,303G2,304 of the width method like each part] WC2. Moreover, the property Fig. expressed with the stair-like property 312 arranged in the center of this drawing shows the normalized-radiam-frequency potential function PYM (Y) which said each field of IDT has. The point averaged and acquired over the whole X shaft orientations of IDT takes cautions to said PYM (Y). The reason in which this is possible is that it is treating the resonator by which reflection of the surface acoustic wave of an infinity time is repeated between reflectors. The relation of Q (Y) and PYM (Y) in the formula (3) which said operation explained by the way is given by the degree type.

[0044]

[Equation 6]

Q(Y) =omega00 {1/eta+(1-1/eta) PYM(Y)} (6)

However, in the Xtal ST cut X propagation substrate which will be explained concretely from now on and which is a 30 to 45-degree rotation Y cut, the value of 0.99-0.95 is taken as eta. Under these conditions, it explains below how said normalized-radiam-frequency potential function PYM (Y) was given. A surface acoustic wave receives a perturbation according to the periodic grids structure with which an electrode finger builds the field which consisted of periodic arrays of an electrode finger first expressed in WC2 and WC12 as WC1, and a rate falls to Vm from the velocity of propagation Vs of the free surface. Therefore, corresponding to Vm, the angular frequency omega 00 (=2piVm/(2PT)) of the above-mentioned field is determined. PT is the array cycle length of an electrode finger. It can be easily understood from a formula (6) that PYM corresponding to this angular frequency is 1. Moreover, PYM to the free surface is PYM=0 and the angular frequency in this case is set to omega 00 (1/eta) (> omega 00). the electric supply shown by BB in drawing 3 -- a conductor -- let the sections be 500 to 1000 ppm, and a little small thing from the rate Vs of the aforementioned free

surface from the surface acoustic wave rate obtained in FEM analysis as complete covering. Therefore, x(0.001= 1 / 0.99-1) PYM corresponding to about PYM=0.1. Since one fourth of the electrode finger numbers of a field WC1 intersects the propagation path of a surface acoustic wave, it is considered that Field A is rate descent of about 0.25. Therefore, it is PYM=0.25. the field where, as for the d section, electrode fingers (310 and 311) exist [the average number of the electrode finger of a propagation path] first about PYM of a joint field finally expressed in fields G1 and G2, and electric supply of 307 -- since the field where a conductor exists is arranged periodically at X shaft orientations, it is set to PYM= (1+0.1) / 2= 0.55. Moreover, the b section is considered the same way and are PYM= (1+0.25) / 2= 0.62. Variation-rate [of the transverse mode generated with the above normalized-radiam-frequency potential function PYM (Y)] V (Y) is the S0 mode (fundamental-wave symmetric mode) of 313 and the A0 mode (fundamental-wave oblique symmetry mode) of 314 which were illustrated at the bottom of drawing 3 .

[0045] Below, it explains using drawing 10 from drawing 4 per [which is obtained by the configuration of this invention] property. The aforementioned property is an example of a concrete design about Xtal ST cut (30 to 45 rotation Y cuts) X propagation bearing. the beginning -- drawing 10 R> 0 -- setting -- the equivalence constant of a SAW resonator, and IDT -- the relation of a logarithm is shown. It is 250MHz as a frequency of said SAW resonator. It carried out. in order to contain to about 2x3mm which is the minimum component size considered for manufacture to be possible with Xtal on said frequency -- the logarithm of IDT -- the sum of the reflector N of M and one side needs to be less than 200. The Q value (resonance acutance of image) (curve 1000) of one SAW resonator and the property of the equivalence series resonance resistance R1 (curve 1001) were shown in the basis of this condition at drawing 10 . the logarithm of IDT -- M -- the range of 40 to 120 -- setting -- about 10,000 or more Q value -- moreover, as for R1, in 60 to 120 pairs of range, about 100ohms is obtained for M. However, 8**1 wave was used as electrode finger crossover

width of face (it is WCT=WC1+G1+WC12+G2+WC2 WCT/2 and here) of one SAW resonator. In this invention, the twice of the aforementioned electrode finger crossover width of face take equally to the total IDT width of face WCT (=WC1+G1+WC12+G2+WC2) of drawing 3 . therefore, said total -- IDT width of face -- 14 to 18 waves -- and the conductor of 120 pairs from a logarithm M60, therefore a reflector -- the property which makes a number 140 to 80, then the purpose of this invention is acquired.

[0046] Next, drawing 4 and drawing 5 are properties which show the relation between the frequency of proper oscillation Mode S 0 andA0 which the horizontal duplex mode SAW filter of this invention has, and the dimension WC12 in drawing 3 . The axis of abscissa was the wavelength unit lambda of the surface acoustic wave in operating state about WC12 among drawing, and an axis of ordinate is frequency rate-of-change deltaf/f, and was expressed per ppm (10-6). 0 ppm in drawing are in the condition corresponding to the resonance frequency of infinity in the electrode finger crossover width of face of a SAW resonator. 400 is the resonance frequency in theScurvilinear of drawing 4 0 mode first. As illustration, from 800 ppm of WC 12= 0 of Point Q, resonance frequency is decreasing toward 360 ppm (401) which is the value of Point P as WC12 increases. About the detailed interpretation of this phenomenon, it mentions later using drawing 8 and drawing 9 . On the other hand, drawing 5 is the resonance frequency (500) in the A0 mode. WC12 shows not changing a lot. He can understand this phenomenon from the resonance frequency in the A0 mode being determined by said WCT. If the resonance frequency difference in the S0 andA0 mode is about 1000 ppm, since the target PHS and the IF filter of a GSM application are realizable from drawing 4 and drawing 5 , it will be good above WC12=2lambda. The upper limit of WC12 was decided from the filter impedance determined from the SAW resonators 1 and 2 setting to 400 to 500 ohms, and should just have been five or less waves. Incidentally, the dimensions G1 and G2 in drawing 3 used about one wave.

[0047] Next, drawing 6 is S11 reflection property seen from the input terminal

side (111 of drawing 1) of the horizontal duplex mode SAW filter of this invention. The axis of abscissa of drawing 6 is frequency rate of change, and an axis of ordinate is the relative value of the value of S11. The frequency in which the value of S11 takes a peak is in a low side to the fundamental-wave symmetric mode S0, and fundamental-wave oblique symmetry mode A0. The delta frequency between S0 andA0 is 1080 ppm. Furthermore, drawing 7 is the transmission characteristic of the filter of drawing 1 , and Sb of an axis of ordinate is the amplitude characteristic of an insertion loss. 3dB pass band width which Sb has is about 1500 ppm, and, in two-step cascade connection of this of drawing 2 , turned into pass band width of about 1000 ppm. However, although the passage area inclines, this is generated when the resonance amplitude in said S0 andA0 mode differs.

[0048] Next, if the structure of this invention of drawing 2 is used, it will explain by being with drawing 8 and drawing 9 about pass band width spreading. Drawing 8 shows the relation of variation-rate [of the normalized-radiam-frequency potential function PYM (Y) and the S0 mode] V (Y) about IDT which takes the uniform structure corresponding to P points of drawing 4 . the electric supply whose IDT800 surrounded with the broken line in drawing connects this with positive/negative electrode fingers -- it consists of conductors 805 and 804. The frequency potential function PYM (Y) which said IDT builds is the property 809 of the lower part of drawing 8 , and supports IDT of a drawing upper case. Since said electrode finger intersection of IDT is arranged uniformly at +X shaft orientations, it becomes as fixed [the frequency potential value of 809] as PYM=1 in this part. S obtained in this condition -- variation-rate V (Y) is a TOTSU function smooth inside like the curve 806 of the middle the 0 mode. The resonance frequency in the S0 mode which has the relation of deltaf/f=a'k2 in approximation small therefore relatively as for the wave number k of the surface acoustic wave of Y shaft orientations in this case serves as a small value relatively (P points of drawing 4). However, said a' is proportional to a in the above-mentioned formula (2). Next, the configuration corresponding to Q points

of drawing 4 is drawing 9 . the condition with which IDT surrounded by the broken line of 900 combined the IDT section of two SAW resonators -- it is -- electric supply of straight polarity -- a conductor 905, the electrode finger 901, and 911 grades -- IDT of the first SAW resonator -- it is -- electric supply of straight polarity -- it is IDT of the 2nd SAW resonator in a conductor 904, the electrode finger 902, and 904 grades. electric supply of negative polarity -- a conductor 906 is formed in one and shared. The frequency potential function PYM (Y) which IDT which the above combined has turns into the step function 909 in the lower berth shortly. electric supply of negative polarity -- it is given like b of the lower berth, and d field for the frequency potential function near the conductor 906, and the same reason as ****3 . in this case, the variation rate with which the S0 mode in which two width of face was small combined diagram [of the S0 mode given] V (Y) in one wave (2b+d) of center like 907 of the middle -- a condition is taken. Therefore, the wave number k of the surface acoustic wave spread to Y shaft orientations (908) serves as a big value relatively, and the relation of the same deltaf/f=a'k2 as the above-mentioned to resonance frequency becomes large relatively. The above is the reason nil why Q points of drawing 3 are bigger than P points.

[0049] Now, when a prototype was built based on the above, on the occasion of the miniaturization of the technical problem 2 which invention tends to solve, broadband-ization of the pass band width of a filter which is 1 of a technical problem was realizable. It was one of these, and as a result of inquiring further, it became clear that some technical problems that an improvement is desired existed. The Q value fall in the fundamental-wave oblique symmetry mode A0 which constitutes a filter if these are enumerated. b) Spurious generating which considers high order in harmonic mode as a cause. C) In the filter shape, it was the increment (40dB) in the magnitude of attenuation out of band. First, these causes and cures are surveyed.

[0050] First, as a result of studying the cause of the above-mentioned a, the cause suited having reduced the Q value of the resonator which constitutes a

filter with the Joule's heat which the forward negative charge generated on the electrode finger of IDT short-circuits and generates. The S0 aforementioned mode is [the 8000-10000, and A0 mode of extent of Q value] about 4000 (each mode is referring to drawing 6).

[0051] The reason from which only said A0 mode became a Q value fall is for internal energy loss to have occurred [to have generated the charge proportional to a variation rate on the electrode finger, and], when a short-circuit current flowed, as a result of said A0 mode's taking the displacement condition of 314 of drawing 3 in the electrode finger field of 315 which is the duplication field of drawing 3 . On the other hand, the S0 mode (313 of drawing 3) is like-pole nature in the duplication field 315, and a short-circuit current does not flow and does not generate an internal loss. Therefore, this cure is making it not produce the short pass of a generating charge as much as possible to said S0 andA0 mode. Moreover, in order to carry out flattening of the passband property of a filter, using resonance amplitude in the S0 andA0 mode as the same, it is required to make the electrode surface product in said mode the same, and to make an accumulation charge total amount into equivalence.

[0052] Next, the result of having studied the cause of b is as follows. In order to set the insertion loss of the horizontal duplex mode SAW filter of this invention to 3 or about 4dB, it is desirable to make Q value in each mode to constitute about into 12000. Then, although increasing electrode layer thickness was known the making the reflection coefficient of a reflector and each electrode finger in IDT increase purpose, when this was performed, the level of the spurious primary horizontal symmetric mode S1 increased. moreover, the electric supply by the side of the negative electrode (touch-down) shown in 115 of drawing 1 , 116, and 117 grades -- depending on the configuration of a conductor, the vertical fundamental-wave oblique symmetry mode LA 0 occurs. as the cure to spurious one of these -- the mode LA 0 -- being related -- said electric supply -- it is making into axial symmetry electrode finger crossover width of face WC (X) formed with a conductor about the center of the longitudinal direction X of a filter.

Moreover, about Mode S 1, the policy which applies the fact about a power flow vector and oppresses said S1 mode was devised.

[0053] As a result of carrying out cause investigation of said C and the elastic wave which the part where the electrode fingers of IDT of an input side and IDT of an output side lap mutually exists, forms a transversal filter partially by this, and does not contribute to resonance phenomena from an input side at an output side leaking next, it is for the magnitude of attenuation out of band to get worse to about 40dB. Therefore, this cure is making it the excitation field of IDT not lap. Although the problem was explained briefly above, a concrete example is raised to below and still more detailed explanation is given.

[0054] First, at first, drawing 11 is other examples of the horizontal duplex mode SAW filter of this invention which took the configuration for insulating electrically between the terminal pairs of an input side and an output side in order to oppress the vertical fundamental-wave oblique symmetry spurious mode LA 0. Drawing 11 makes two-step subordination connection of the SAW filter of 2 pole molds like drawing 2 . Respectively the piezo electric crystal plate with which 1100 consists of Xtal etc. in the name like each part in drawing, and 1101 and 1102 The 1st and the 2nd SAW filter, The whole IDT with which 1103 doubled the input side and the output side, a reflector with common 104 and 105, The positive-electrode side input terminal of the 1st SAW filter and 1107 1106 The input terminal by the side of a negative electrode, the electric supply by the side of the negative electrode a positive-electrode side edge child, and whose 1110 and 1111 1108 and 1109 were one in drawing 1 as for the terminal by the side of the negative electrode of the output side of the 1st SAW filter, and 1113 -- a conductor is divided into two as it is also at interval spare time in the center. Moreover, 1114 is a Y-axis and 1115 is the X-axis. Since 2nd SAW filter 1102 is the same as that of the 1st, explanation is omitted. the main point of drawing 11 -- the electric supply by the side of the above-mentioned negative electrode -- it is that the conductor is dividing into two, and that the electrode finger crossover width of face WC (X) which IDT has is axial symmetry about Chuo Line (it is

equivalent to Y-axis 1114) of the aforementioned X shaft orientations. This was further explained in full detail to drawing 12 . The axis of abscissa 1203 in drawing 12 is the same as that of the X-axis of drawing 11 . An axis of ordinate is the relative value of the electrode finger crossover width of face WC (X) which IDT of an input side has, and (1202). It is the case where spurious one which the stair-like function 1200 becomes from the vertical fundamental-wave oblique symmetry mode LA 0 of this invention does not occur, and 1201 is the case where spurious one which consists of said LA0 mode occurs. A function 1200 divides the overall length X of IDT into four equally, and has even times (2 times in this case) of the points changing [WC]. Said longitudinal-mode spurious [0] LA is shown by 1601 in the filter transmission characteristic Fig. by this invention of drawing 16 .

[0055] Below, drawing 13 is one example of the electrode pattern for improving the resonance acutance of image, i.e., QA, and QS value in the S0 andA0 mode which constitutes the horizontal duplex mode SAW filter of this invention, and supposing that it is equivalent, and showed the whole one half. The X-axis which has arranged 1301 in drawing in the center of a width method, and 1302 are Y-axes. The field of 1303 and 1304 is a part which approaches the X-axis of 1301 and is dividing the electrode finger 1310 grade in the thin tooth space in front on the right. The electrode finger 1309 which connected with the straight polarity side also in the field 1305 is separated similarly. Therefore, only a part at least for the separated electrode finger part to have dissociated from the condition of having connected 1312 to the positive electrode 1309 does not short-circuit the positive charge in said A0 mode, but energy loss can be mitigated. the fields 1305 and 1306 applied thinly are gross areas which the effective electrode finger crossover width of face WCA of IDT of an each input side and an output side (X) forms (it did not come out especially WC and mentioned specially as WCA), and its area is [1305 and 1306] equal. By doing in this way, said amount of net charge which S0 and AO accumulate becomes equal, and the passage property of a filter becomes flat. Moreover, if the arrangement configuration of 1303 and

1305 of drawing 1313 is taken, since the electrode finger crossover width of face WCA of an input and an output side IDT will not lap, the magnitude of attenuation of 1604 out of band of drawing 16 decreases from -40dB to about -60dB.

[0056] Next, the configuration for oppressing said S1 mode spurious (1602 dotted lines of drawing 16) to drawing 14 is shown. 1400 in drawing is the X-axis and 1401 is a Y-axis. 1402 in a broken line is a field for making the variation rate in said S1 mode reveal which consists of an electrode field of the shape of a grating of this invention, and this consists of electrode fingers which separate the space length G on the left of the electrode finger field 1411 of IDT, and have the same electrode cycle length (almost the same as that of wavelength lambda=2PT of a surface acoustic wave) as IDT1411 covering the maximum width BP. The aforementioned width of face BP can give the dimension which makes a taper configuration to X shaft orientations, and changes to them. electric supply for 1403 to short-circuit the edge of said electrode fingers -- a conductor, and 1404 and 1405 grades call an electrode finger and delta of 1406 a tilt angle on the square of said X-axis 1400 direction and the line of the inside edge of 1403 to accomplish. 1407 is a reflector and the left end section of a reflector is mostly in agreement with the right end section of said grating-like electrode field. this drawing -- the variation rate in said S1 mode in case, as for 1408 (broken line) of the middle, said grating-like electrode-fingers field of 1402 does not exist -- the variation rate in condition V (Y) and said S1 mode in case said grating-like electrode field exists -- Condition V -- ' -- 1409 (continuous line) is illustrated. Furthermore, the stair-like function 1401 of this drawing lower berth illustrates the average frequency potential function PYM (Y) which the field on the Y-axis of the IDT part of drawing 14 has.

[0057] Below, the configuration of drawing 14 can explain signs that said S1 mode is oppressed, using drawing 15 and drawing 17 . Drawing 15 is a situation of the frequency change (deltaf/f (ppm)) at the time of changing said width of face BP which the horizontal fundamental-wave symmetric mode S0 (1501) which is each oscillation mode which the configuration of said drawing 14 has, the

horizontal fundamental-wave oblique symmetry mode A0 (1502), and the primary horizontal symmetric mode S1 (1503) show first. These properties are calculated by the above-mentioned theoretical formula (4) and (5). Even if said S0 andA0 mode changes said width of face BP, it hardly changes, so that it may see by drawing 15 . On the other hand, the descent phenomenon of a frequency has generated [BP] said S1 mode by making the space length G into a parameter more than 2lambda. As for this phenomenon, BP dimension from which a frequency descent phenomenon begins becomes small, so that the space length G is small. This shows that the variation rate in the S1 mode leaks to the field of an outside 1402, so that G is small, the wave number k of Y shaft orientations decreases as a result of vibration displacement's spreading like 1409, and a frequency descends. Although the vibrational energy leaked to 1402 fields of said drawing 14 is spread to X shaft orientations as a surface acoustic wave, since it shifts from the field which a reflector 1407 covers, as a result of being leaked and lost, without being reflected, the Q value in the S1 mode decreases. Thus, oppression in the S1 mode is performed. It considers a point with desirable to the miniaturization of a component as said BP and G dimension range making BP dimension small as much as possible, and that vibration of the S0 and A0 mode is not spoiled, and the four-wave range has the three-wave range and the good range of BP from three waves from two waves (lambda) in the range of G. Moreover, said tilt angle delta is a gap angle over the power flow angle which shows the maximum propagation direction of the surface acoustic wave energy which a piezo electric crystal plate originally has, and showed the relation of Q value which one SAW resonator to said tilt angle delta shows to drawing 17 . The axis of abscissa in drawing is a tilt angle (degree), and an axis of ordinate is Q value. If tilt angle delta is two to about three, Q value can be reduced by half to delta= 0. this effectiveness -- vibration -- the electric supply in which that it is only strange has a tilt angle -- it is effective only in said S1 mode in which a conductor (1403 of drawing 14) is reached. As a result of taking the above measures against S1 mode oppression, the oppression effectiveness in said S1 mode in

the horizontal duplex mode SAW filter of this invention can be oppressed from conventional -20dB to about -40dB. The situation was shown in 1602 and 1603 of drawing 16 .

[0058] In the above, it explained per the configuration of the horizontal duplex mode SAW filter of this invention, and property. Although the Xtal ST cut showed the example of a configuration, the latest-starting-time cut which is the 16-degree rotation Y cut which are other cuts, and K cut which is a 9.6-degree rotation Y cut are sufficient, and it is added that it can suit even if it is piezo-electric materials other than Xtal further again.

[0059]

[Effect of the Invention] As stated above, according to this invention, it faces achieving the miniaturization of a horizontal duplex mode SAW filter, for example using the Xtal substrate. When unifying IDT of two SAW resonators which constitute said SAW filter the electric supply by the side of the negative polarity to share -- by taking two or more two or more locations to the cross direction Y of a component, and repeating a conductor periodically by turns in the propagation direction X of a surface acoustic wave Since the delta frequency between the fundamental-wave symmetric mode S0 which are two independent resonance modes which compound the property of a filter, and the fundamental-wave oblique symmetry mode A0 can be extended more sharply than before, the pass band width of a horizontal duplex mode SAW filter can be extended 30% -- the frequency span between channels, such as PHS, can provide a commercial scene with the intermediate frequency filter of a large communication device application. further -- again -- the logarithm of IDT -- as compared with the former, said filter with a component plane area as small as one half and good is realizable by designing M few with 60 to 120 pairs. Moreover, since it can oppress by constituting the electrode field of the shape of a grating the symmetry of IDT crossover width of face and vibration displacement are made to leak higher-mode spurious in every direction generated by making electrode layer thickness and a width method increase in this case, it can realize, a property is

excellent and said filter excellent in the magnitude of attenuation of a filter out of band can be contributed to implementation of a small communication device.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The top view showing the conductor pattern which one example of the horizontal duplex mode SAW filter of this invention has.

[Drawing 2] Drawing which one example of the horizontal duplex mode SAW filter which carried out two-step cascade connection of this invention shows.

[Drawing 3] The top view which one example of IDT of the horizontal duplex mode SAW filter of this invention shows.

[Drawing 4] The property Fig. which drawing 1 of this invention shows.

[Drawing 5] Other property Figs. which drawing 1 of this invention shows.

[Drawing 6] Other property Figs. which drawing 1 of this invention shows.

[Drawing 7] The property Fig. which drawing 1 of this invention shows.

[Drawing 8] The outline Fig. concerning IDT of uniform structure conventionally.

[Drawing 9] The outline Fig. about IDT of the conventional horizontal duplex mode SAW filter.

[Drawing 10] The property Fig. of the SAW resonator which is the component of this invention.
[Drawing 11] The top view showing the conductor pattern which other examples of the horizontal duplex mode SAW filter of this invention aiming at oppressing the fundamental-wave length oblique symmetry spurious mode LA 0 have.
[Drawing 12] Drawing showing the electrode finger crossover width of face WC which drawing 11 of this invention has.
[Drawing 13] The top view which one example of the conductor pattern which IDT of the horizontal duplex mode SAW filter of this invention shows shows.
[Drawing 14] The top view showing the conductor pattern which other examples of the horizontal duplex mode SAW filter of this invention aiming at horizontal high order spurious oppression have.
[Drawing 15] The property Fig. which drawing 14 of this invention shows.
[Drawing 16] The transmission characteristic Fig. of the filter which drawing 11 and drawing 14 of this invention show.
[Drawing 17] The Q value property Fig. of a resonator which drawing 14 of this invention shows.
[Description of Notations]
100 Piezo Electric Crystal Plate
101 IDT
102 Reflector 1
103 Reflector 2
104,106 An input and output IDT
105 Duplication Field

[Translation done.]

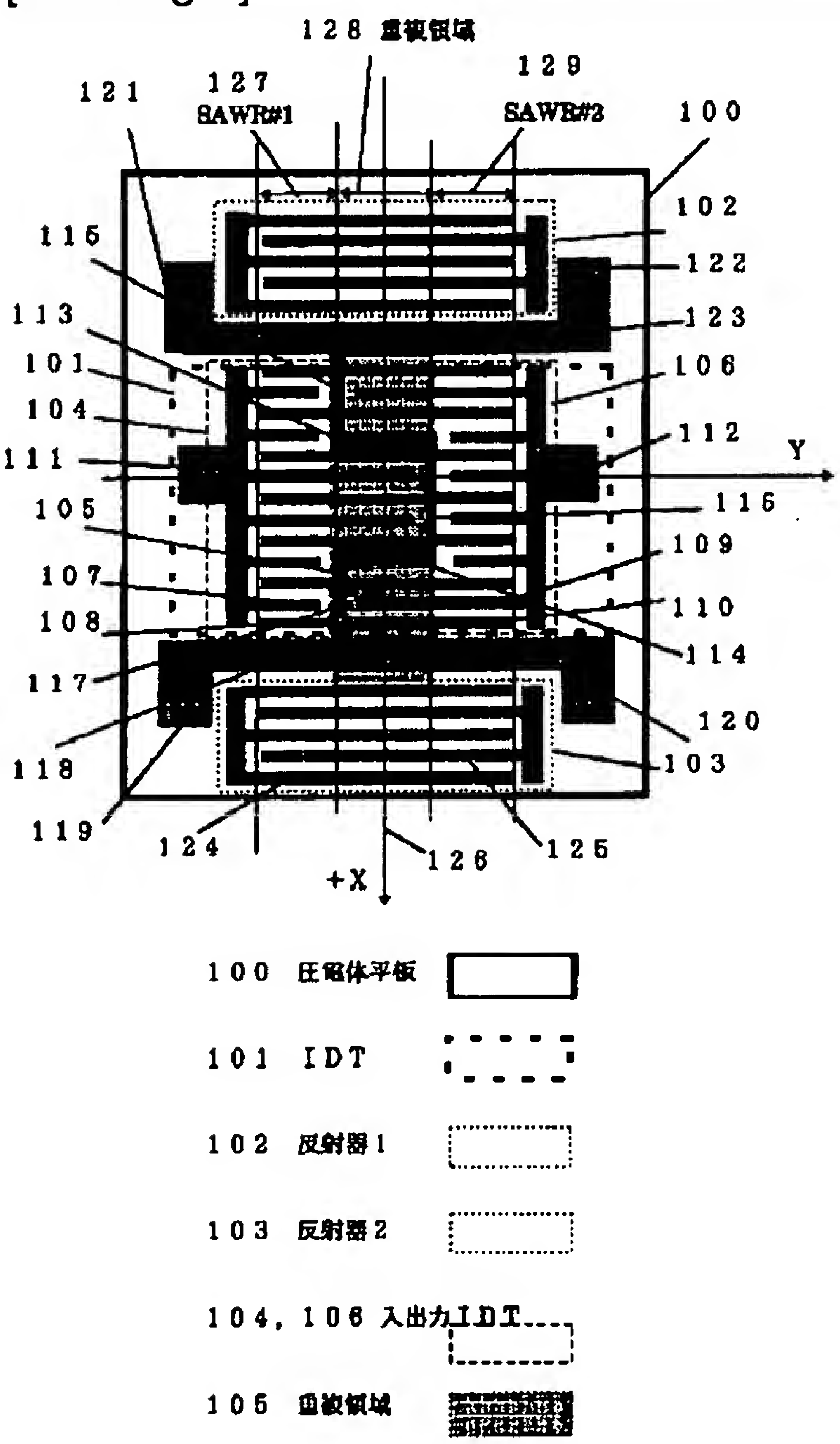
1.This document has been translated by computer. So the translation may not reflect the original precisely.

2.**** shows the word which can not be translated.

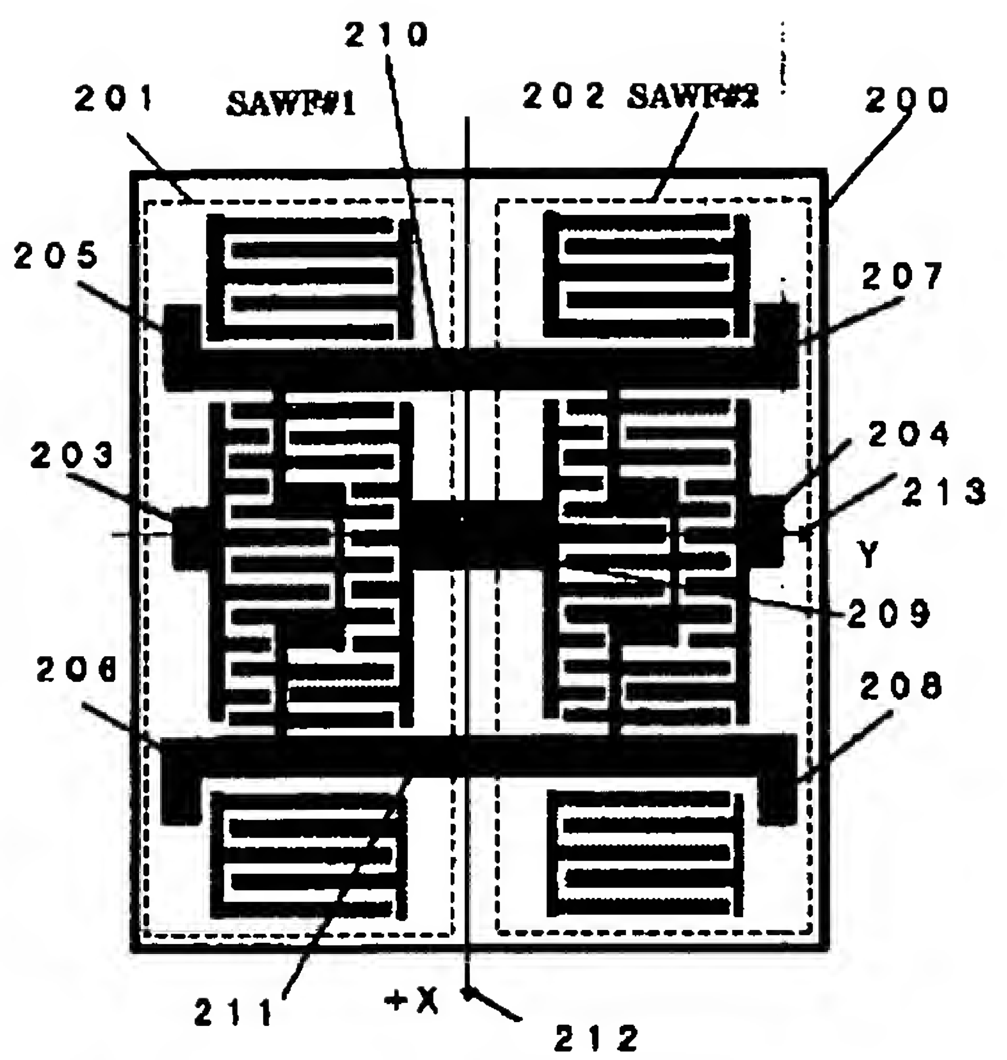
3.In the drawings, any words are not translated.

DRAWINGS

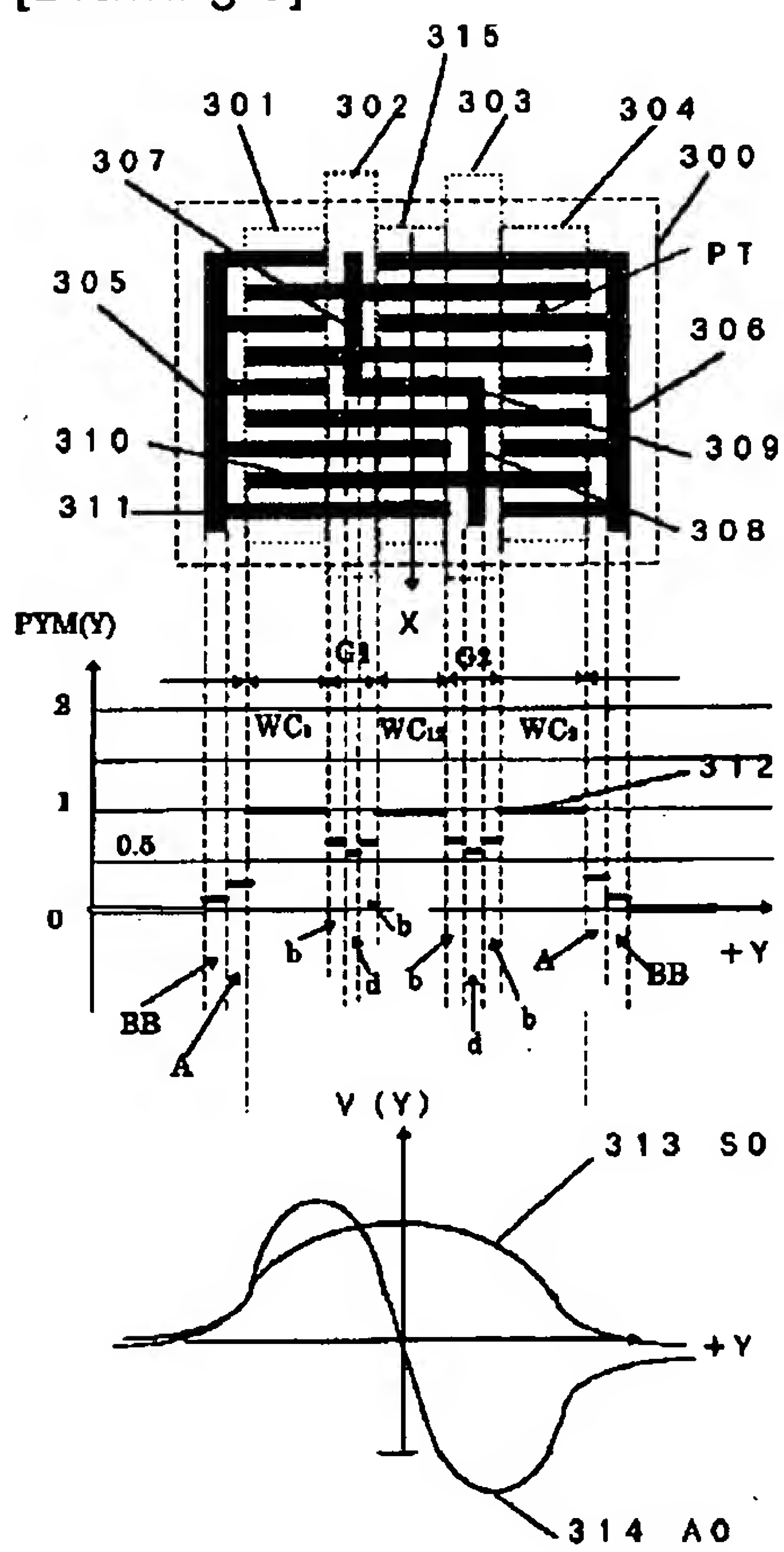
[Drawing 1]



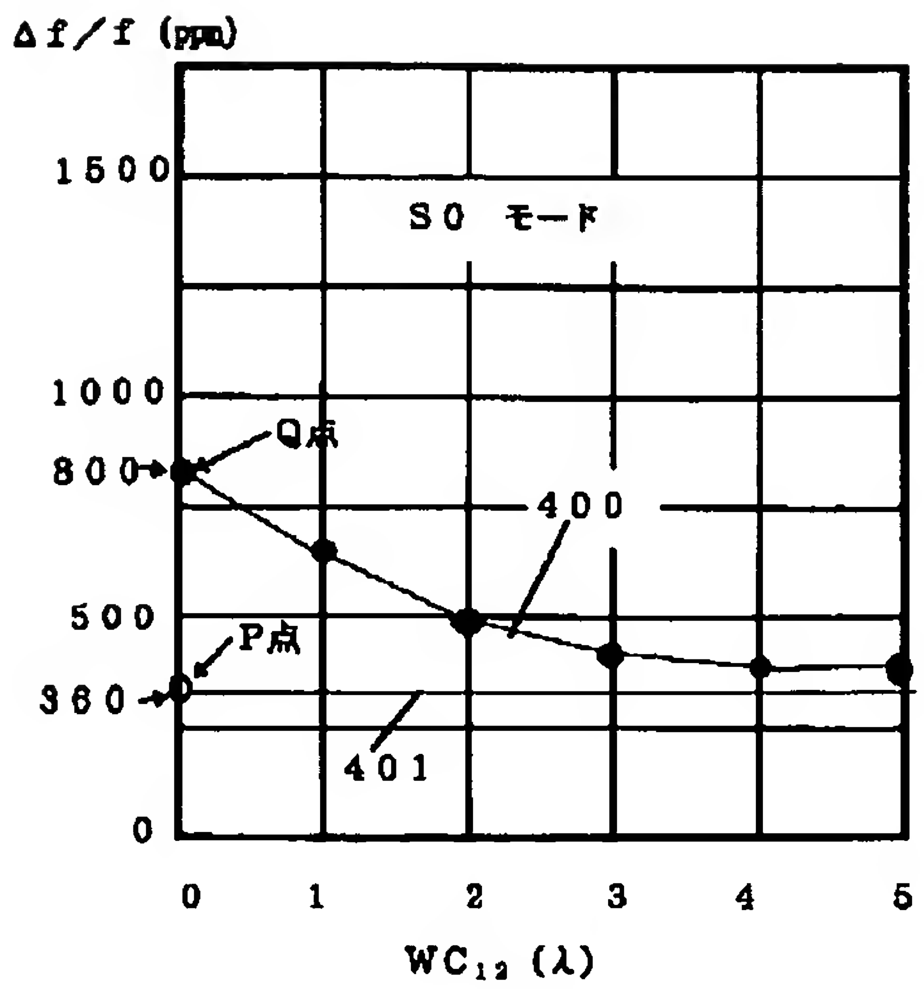
[Drawing 2]



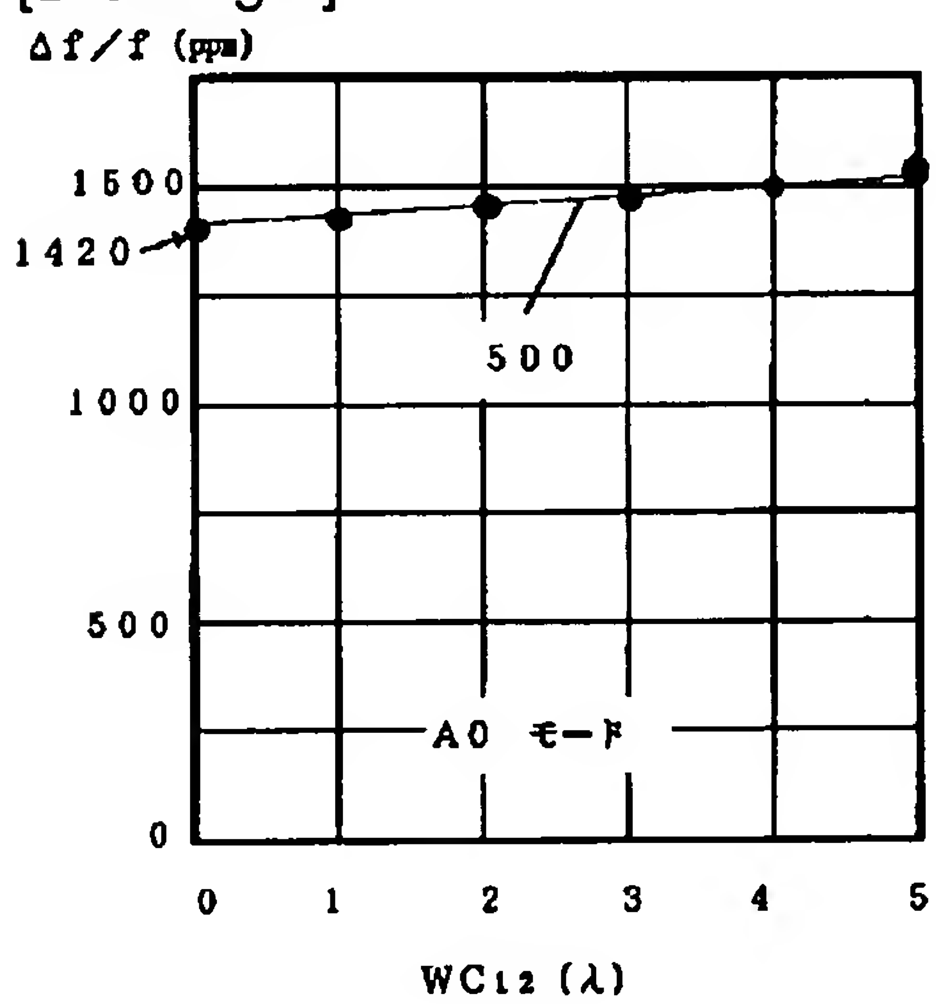
[Drawing 3]



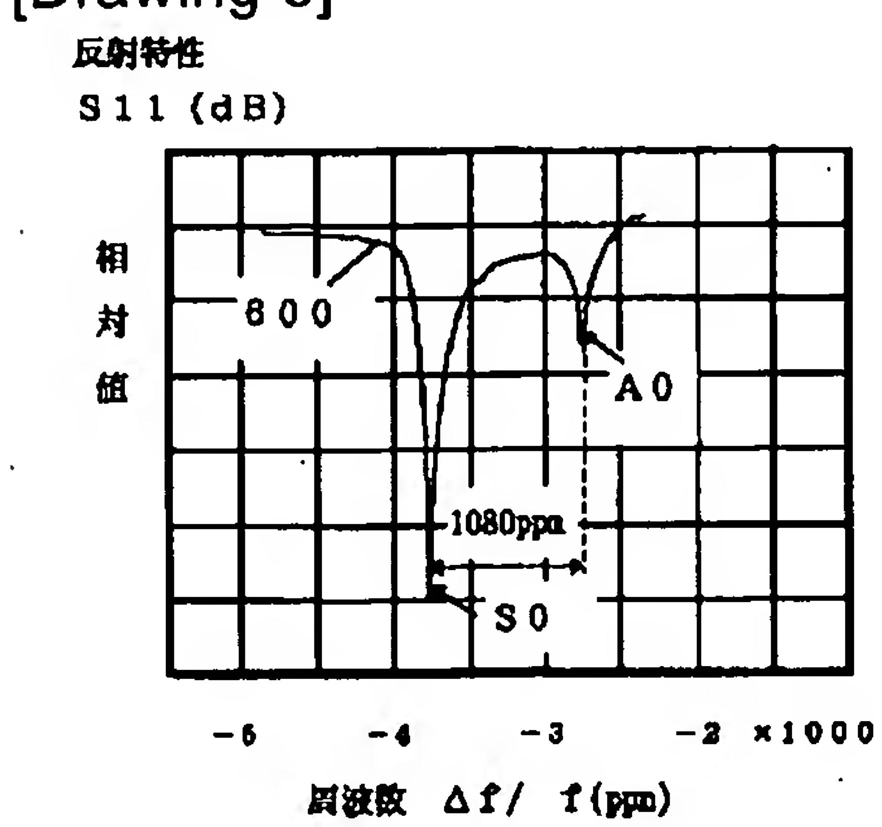
[Drawing 4]



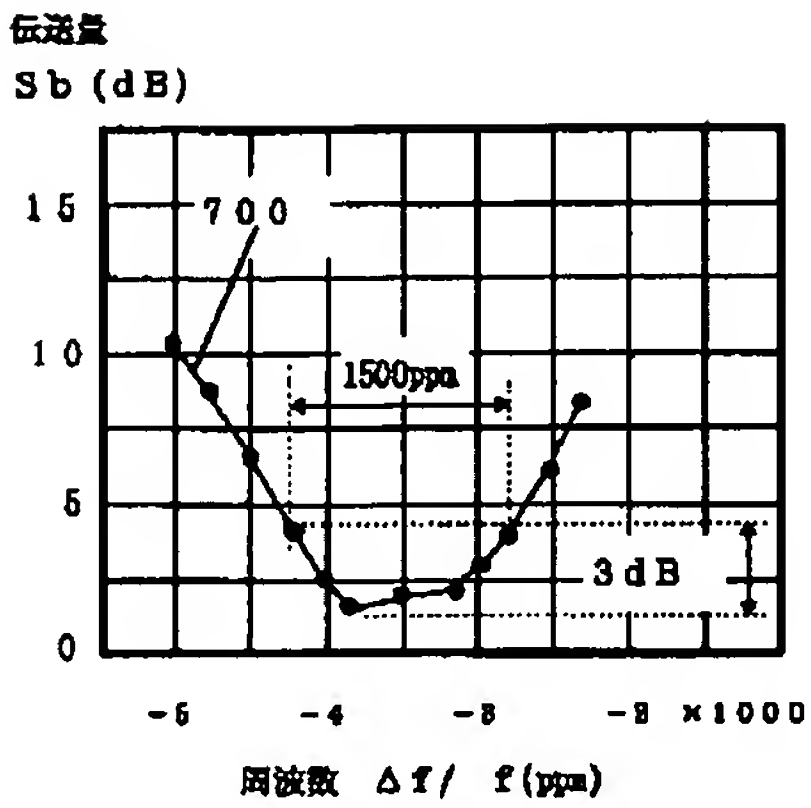
[Drawing 5]



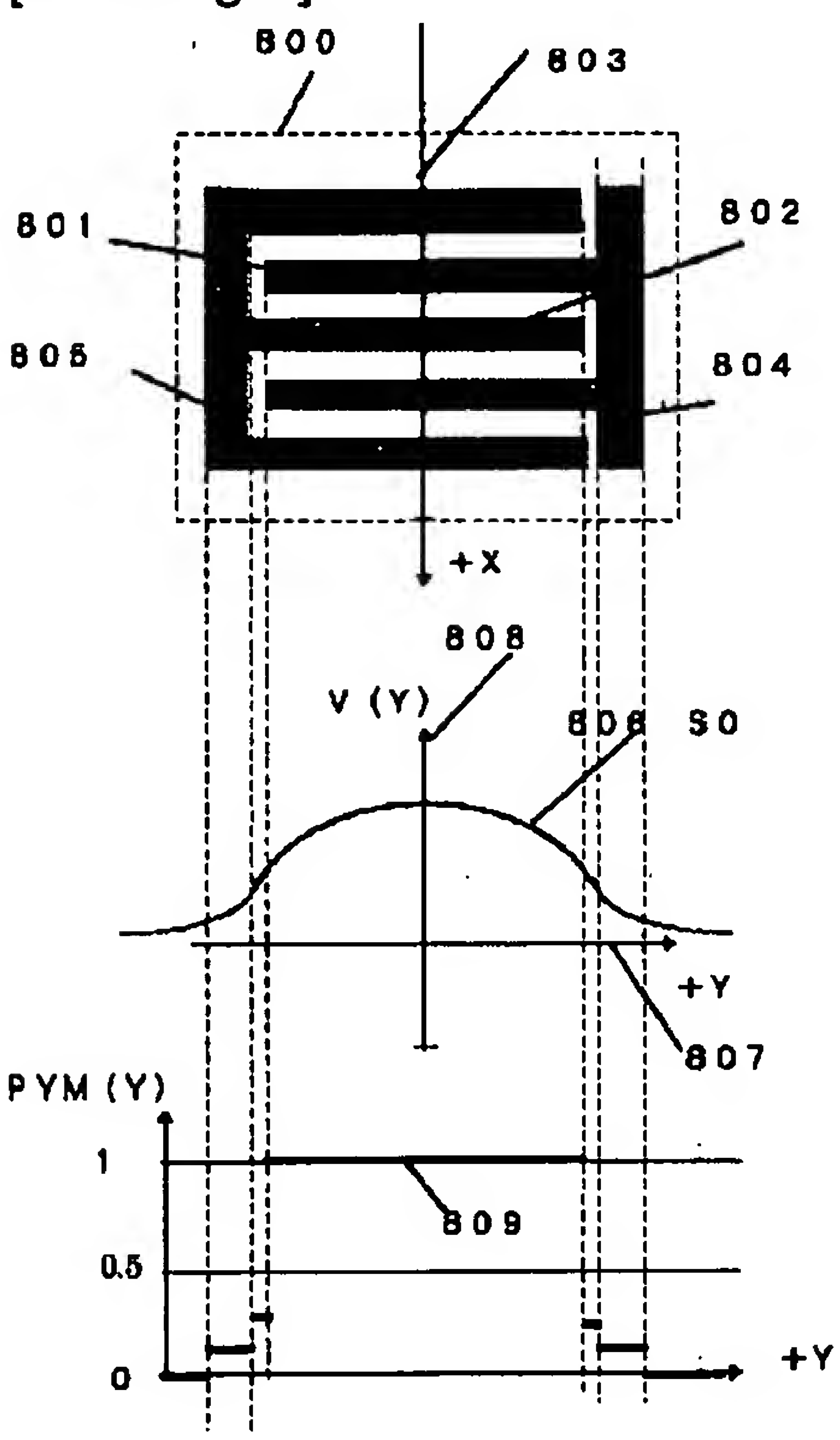
[Drawing 6]



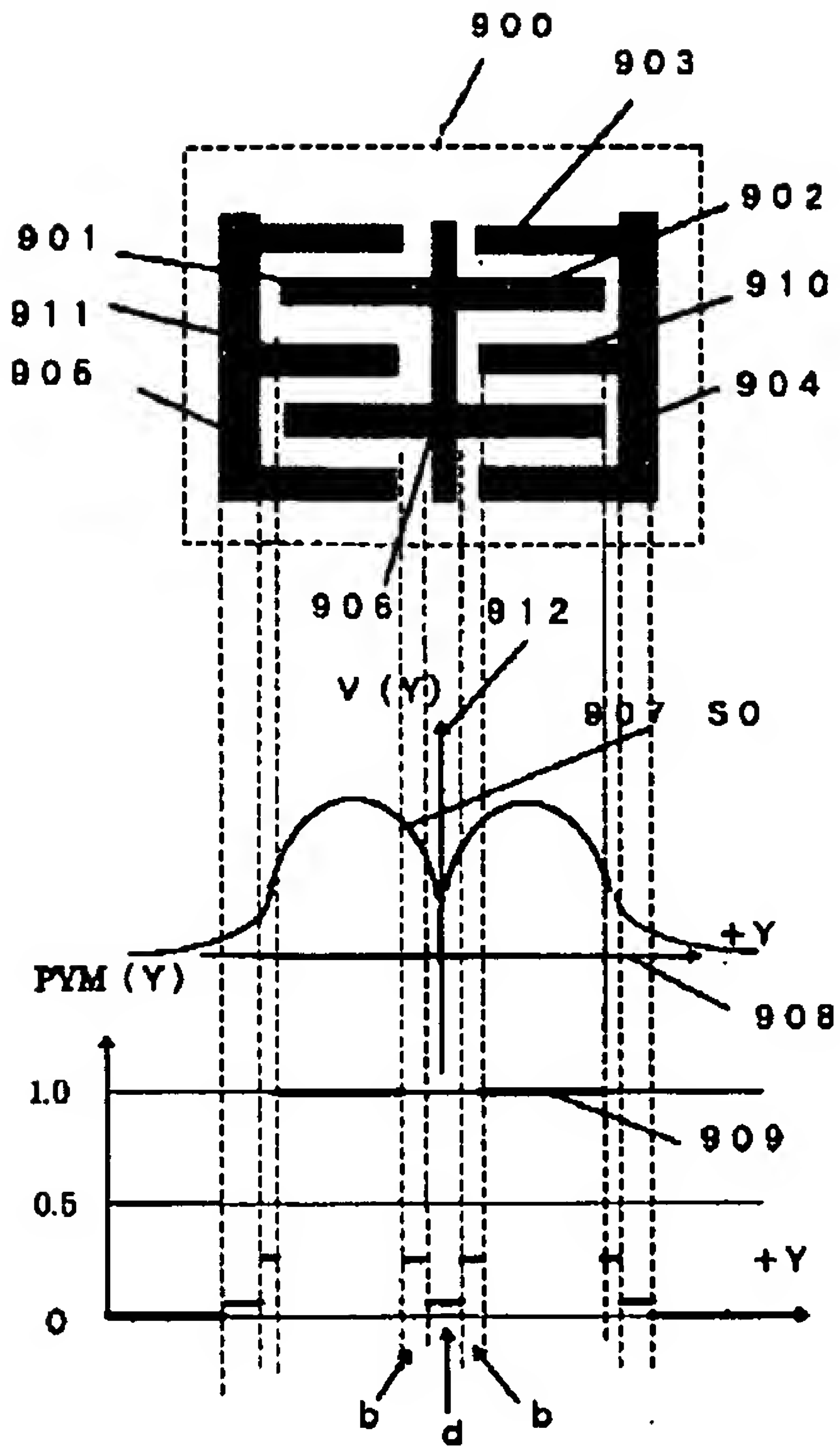
[Drawing 7]



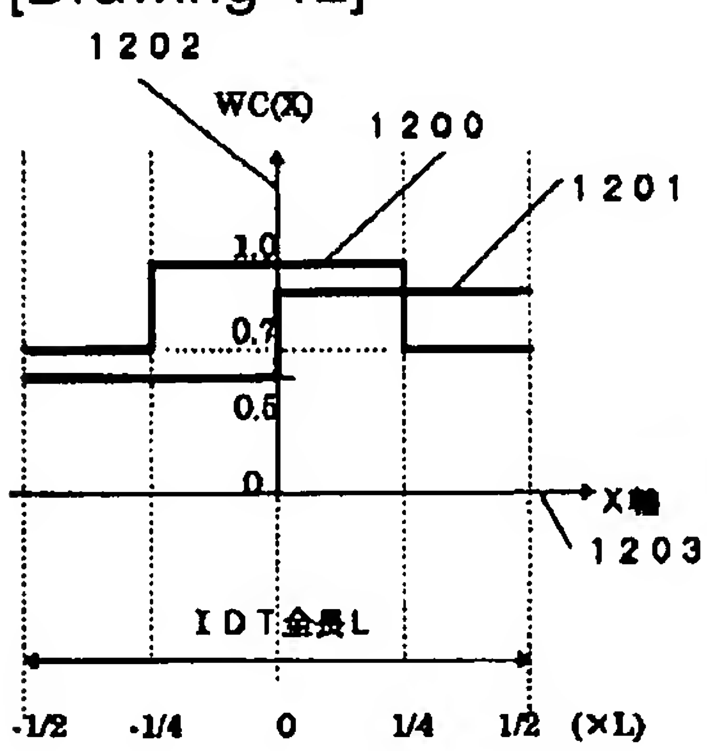
[Drawing 8]



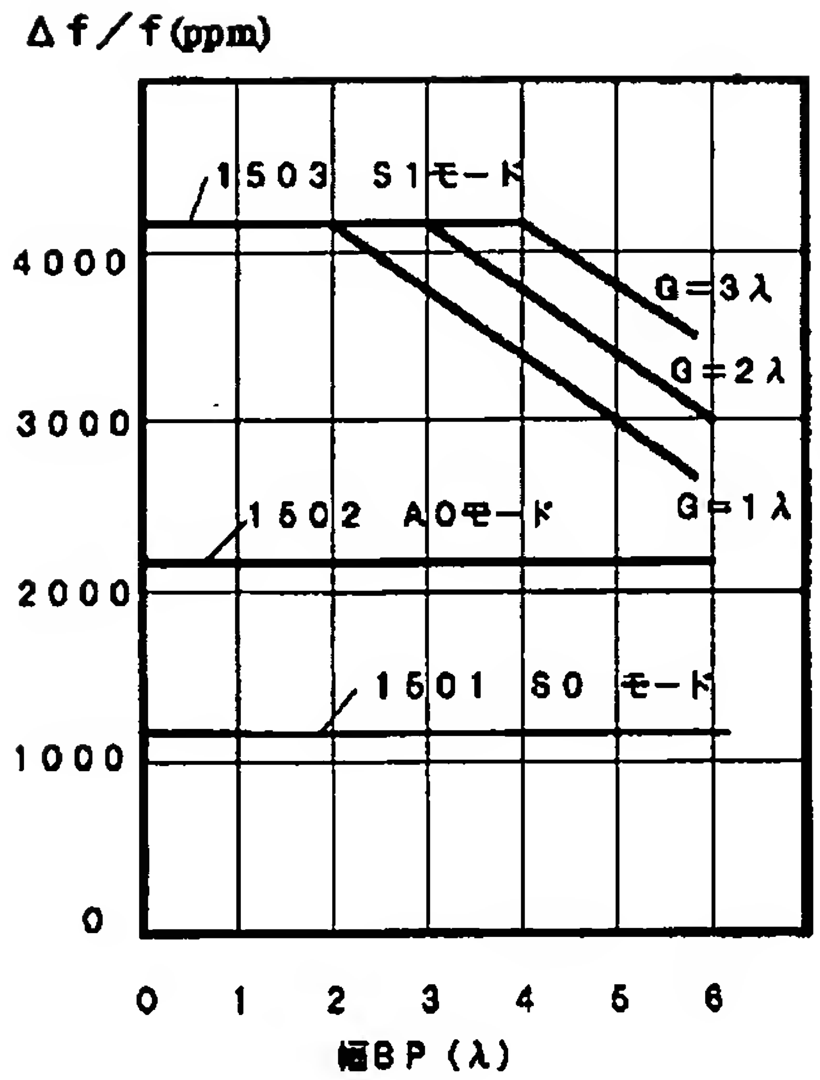
[Drawing 9]



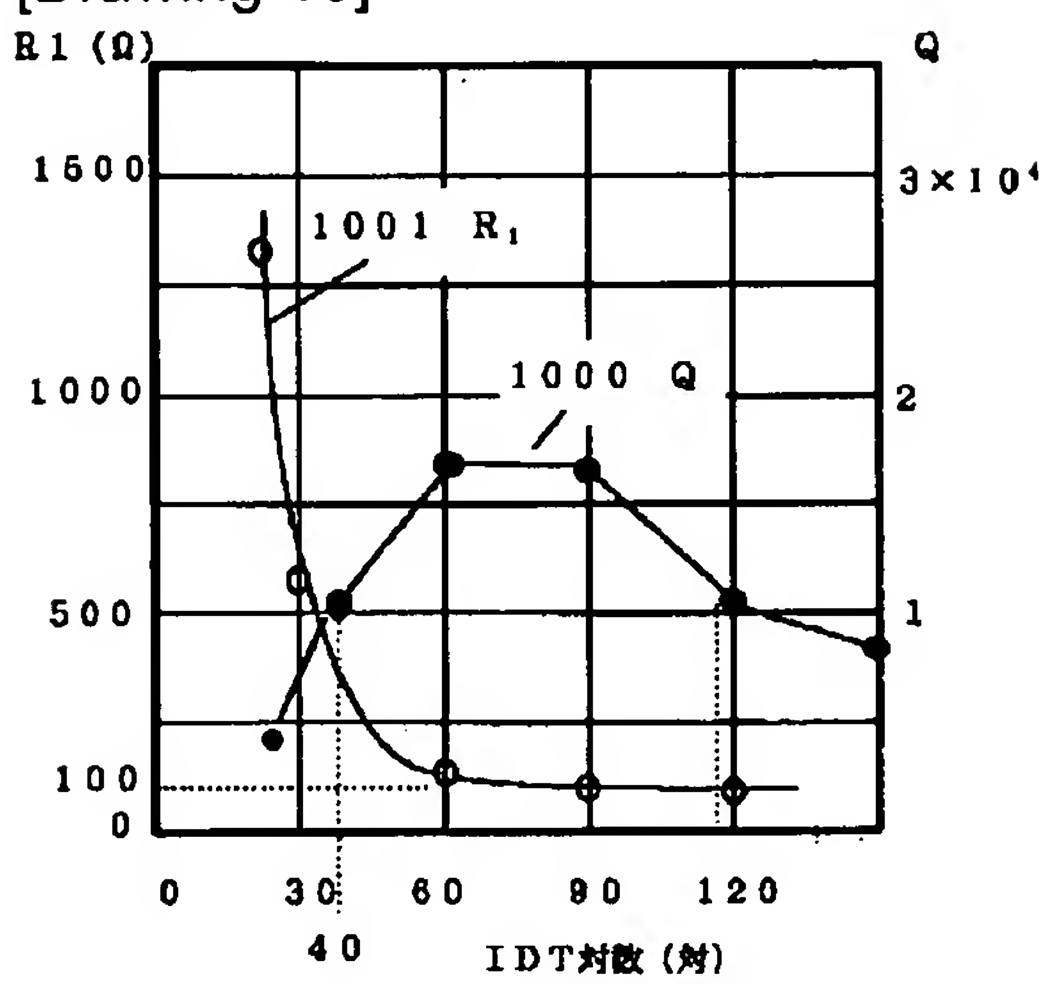
[Drawing 12]



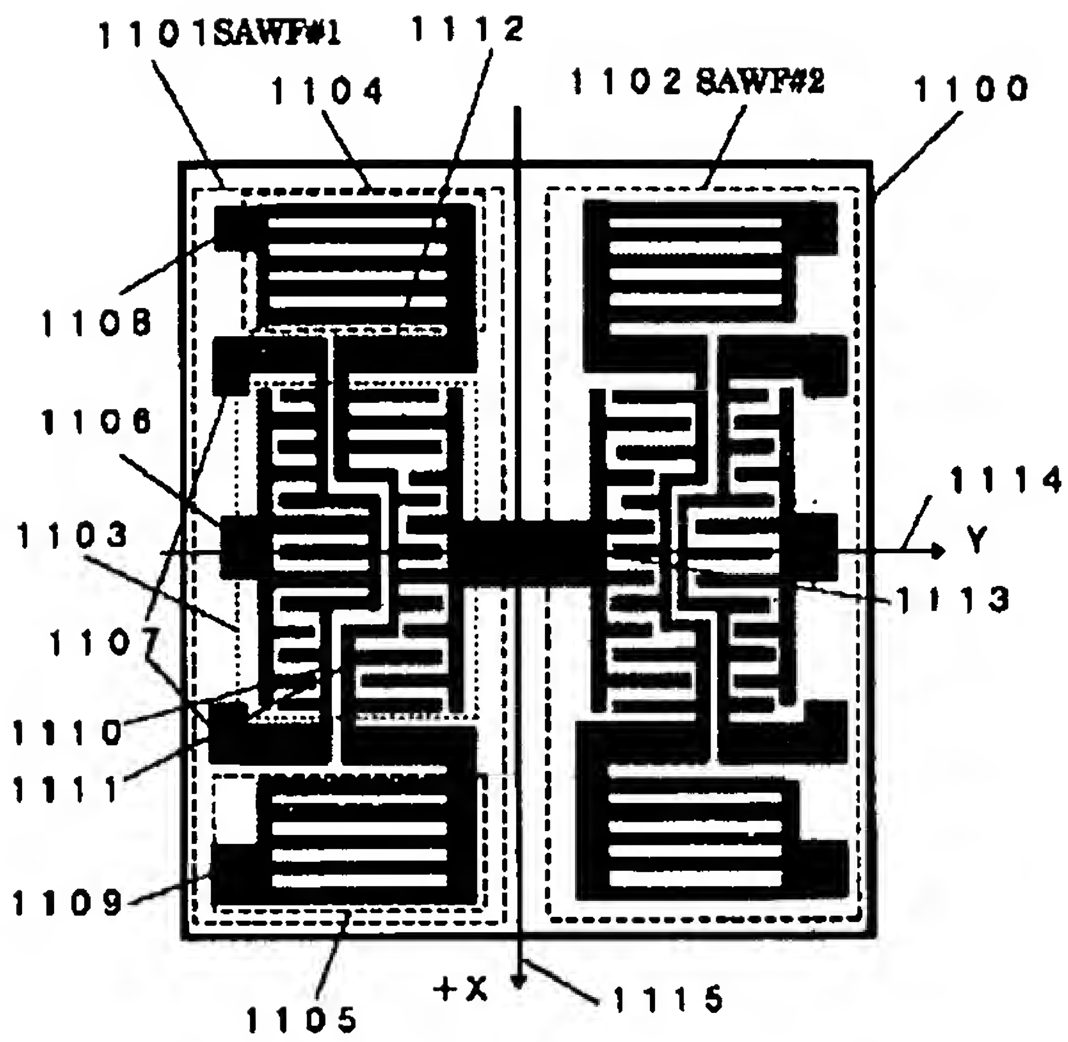
[Drawing 15]



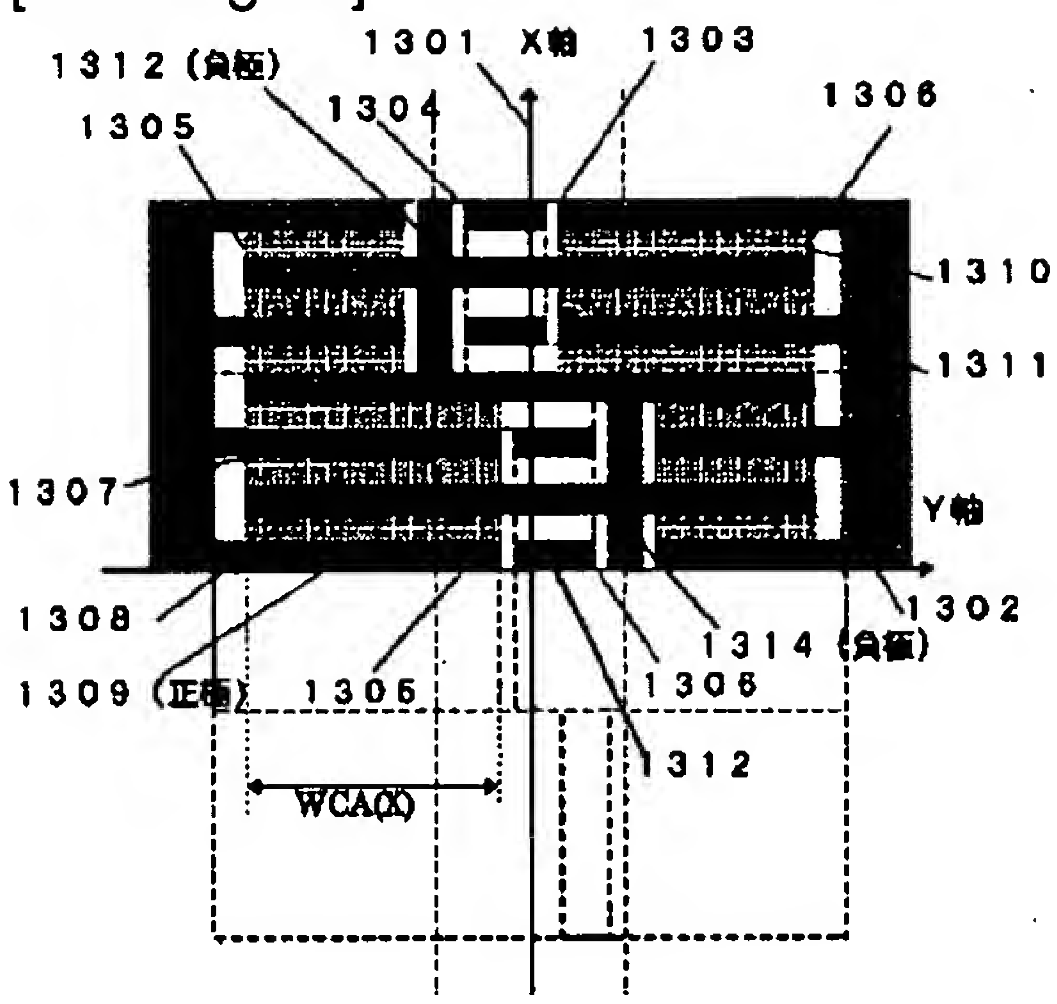
[Drawing 10]



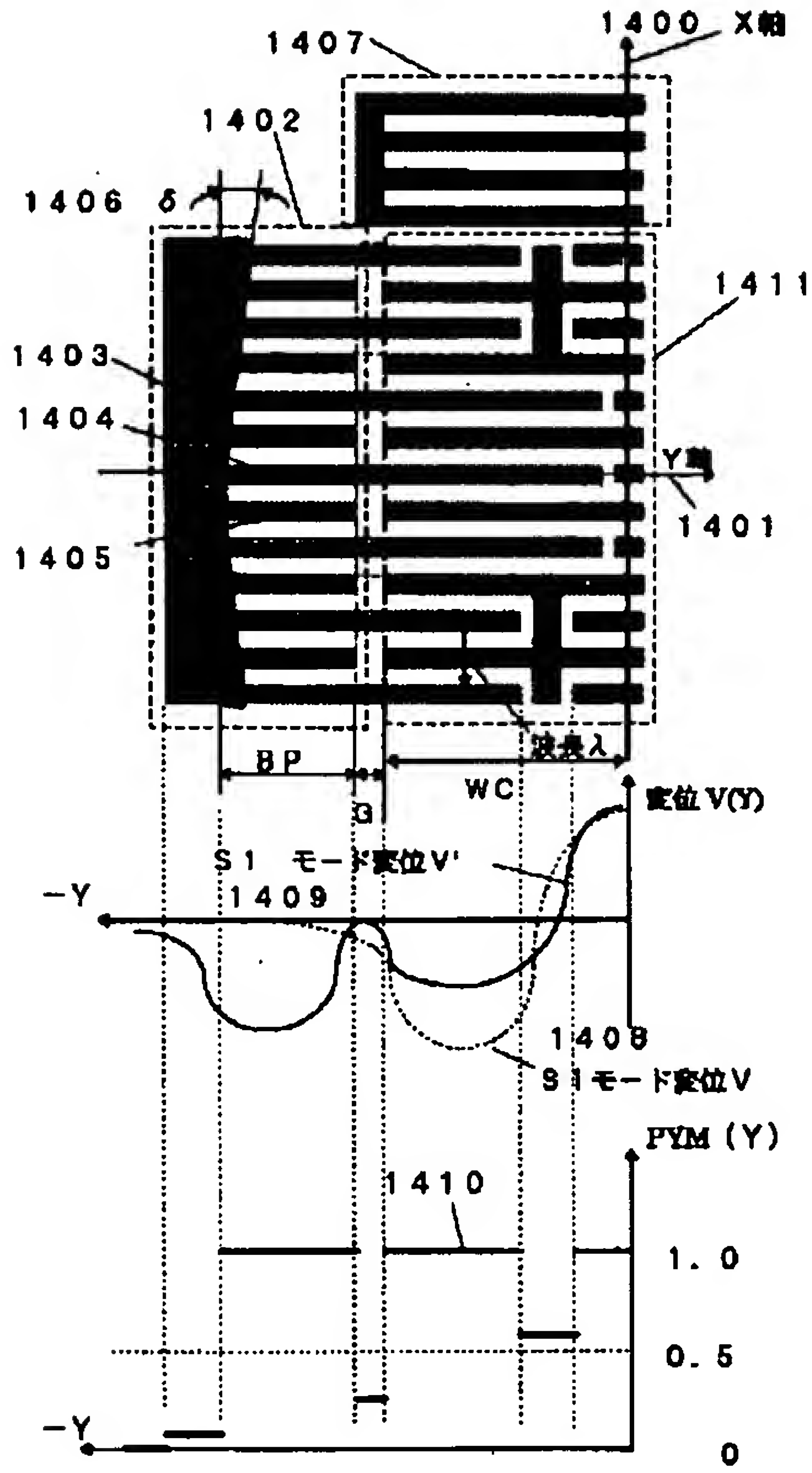
[Drawing 11]



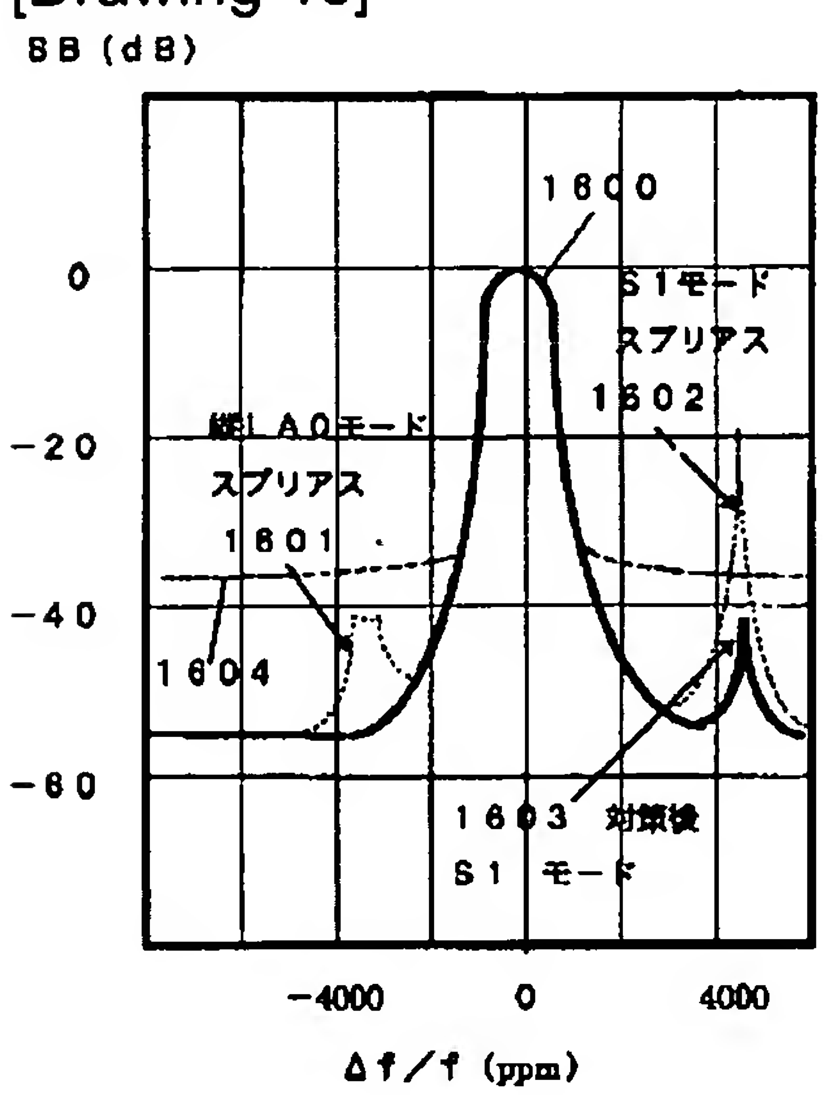
[Drawing 13]



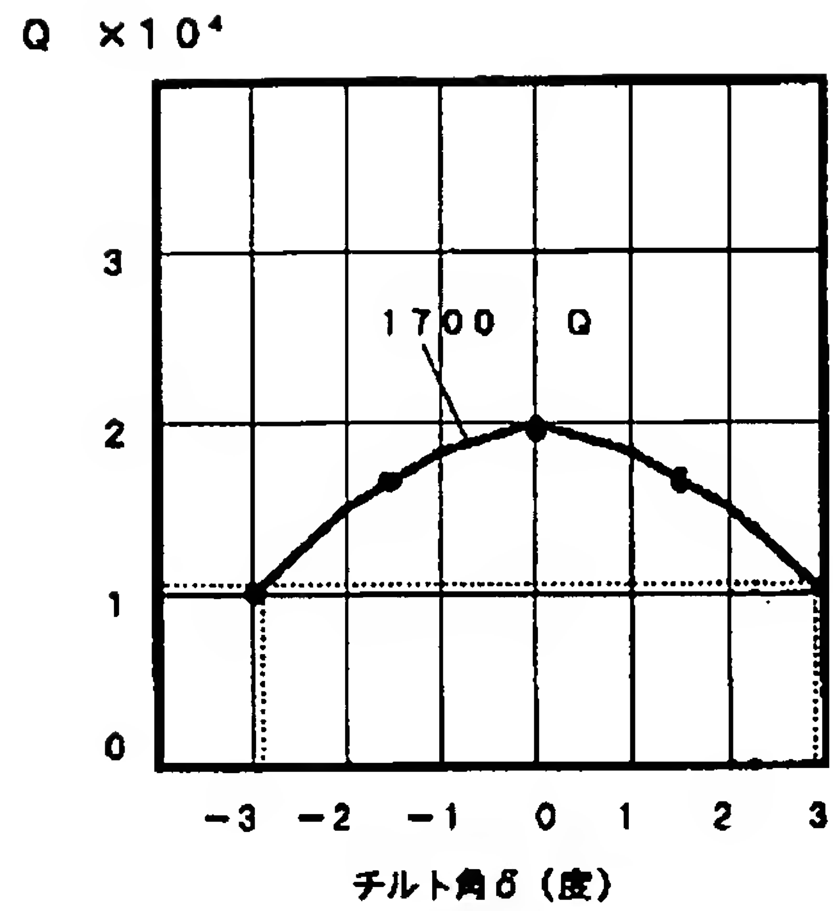
[Drawing 14]



[Drawing 16]



[Drawing 17]



[Translation done.]